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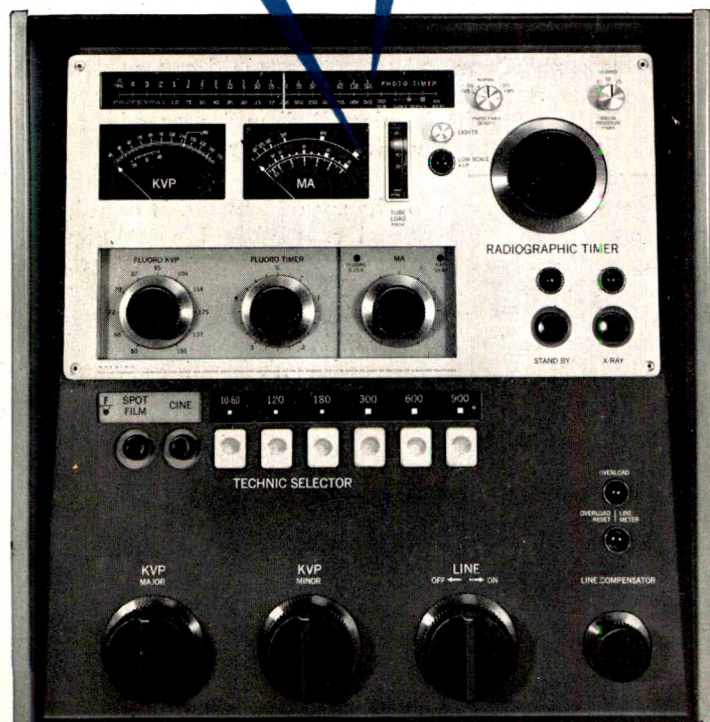
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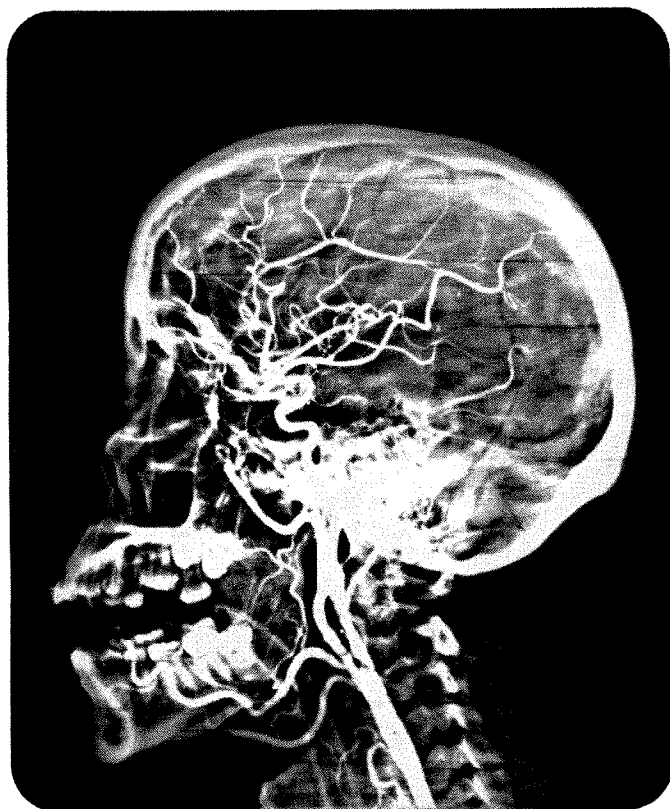
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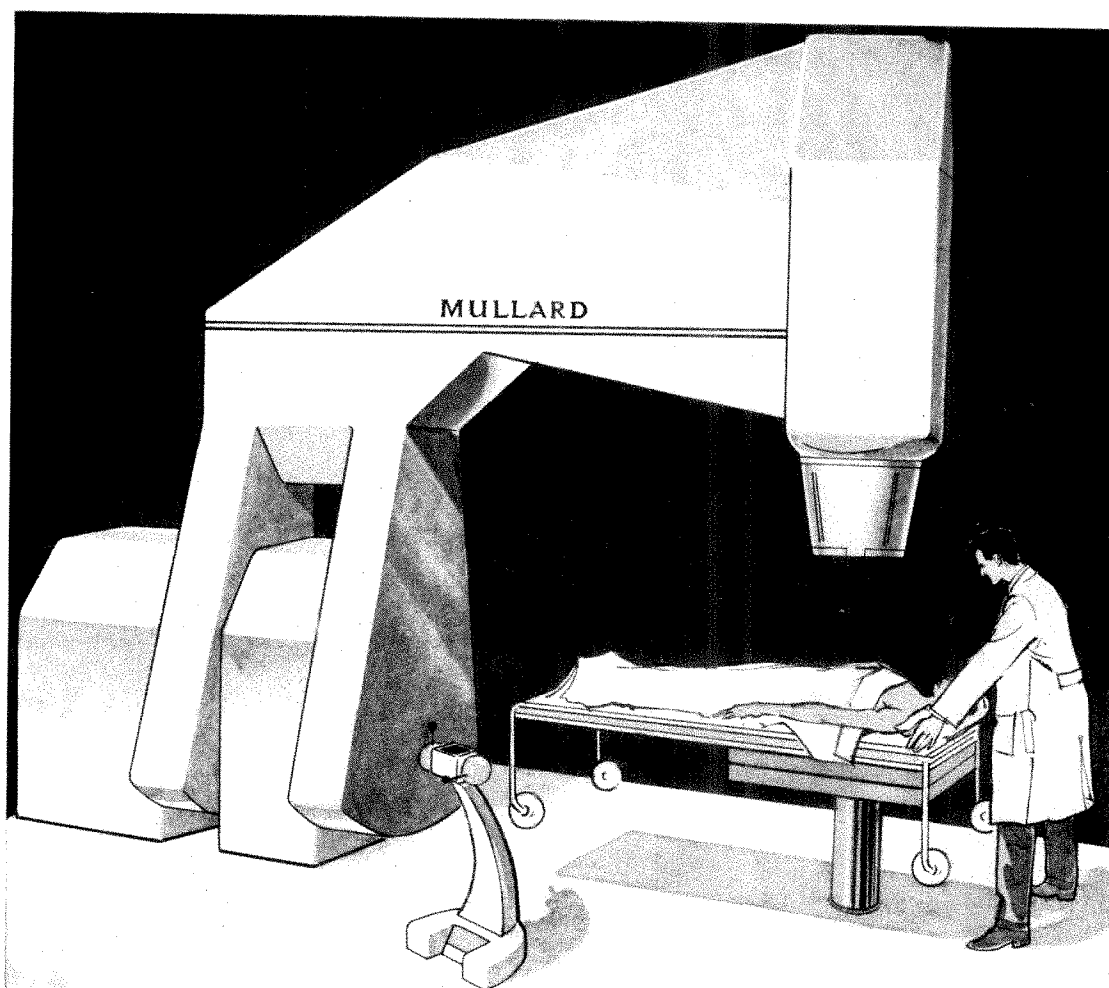
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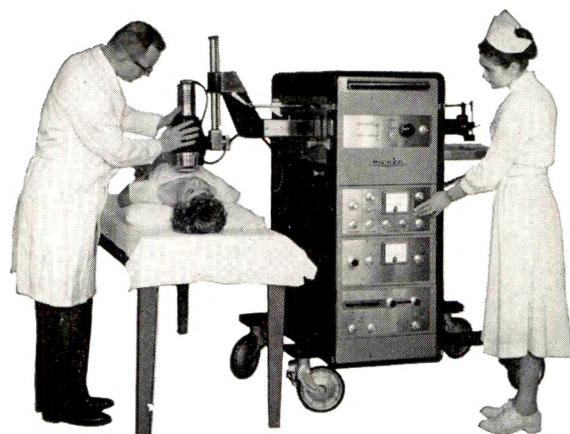
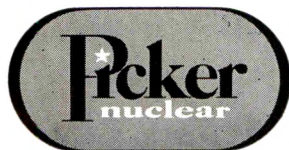
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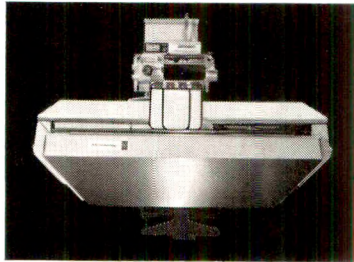
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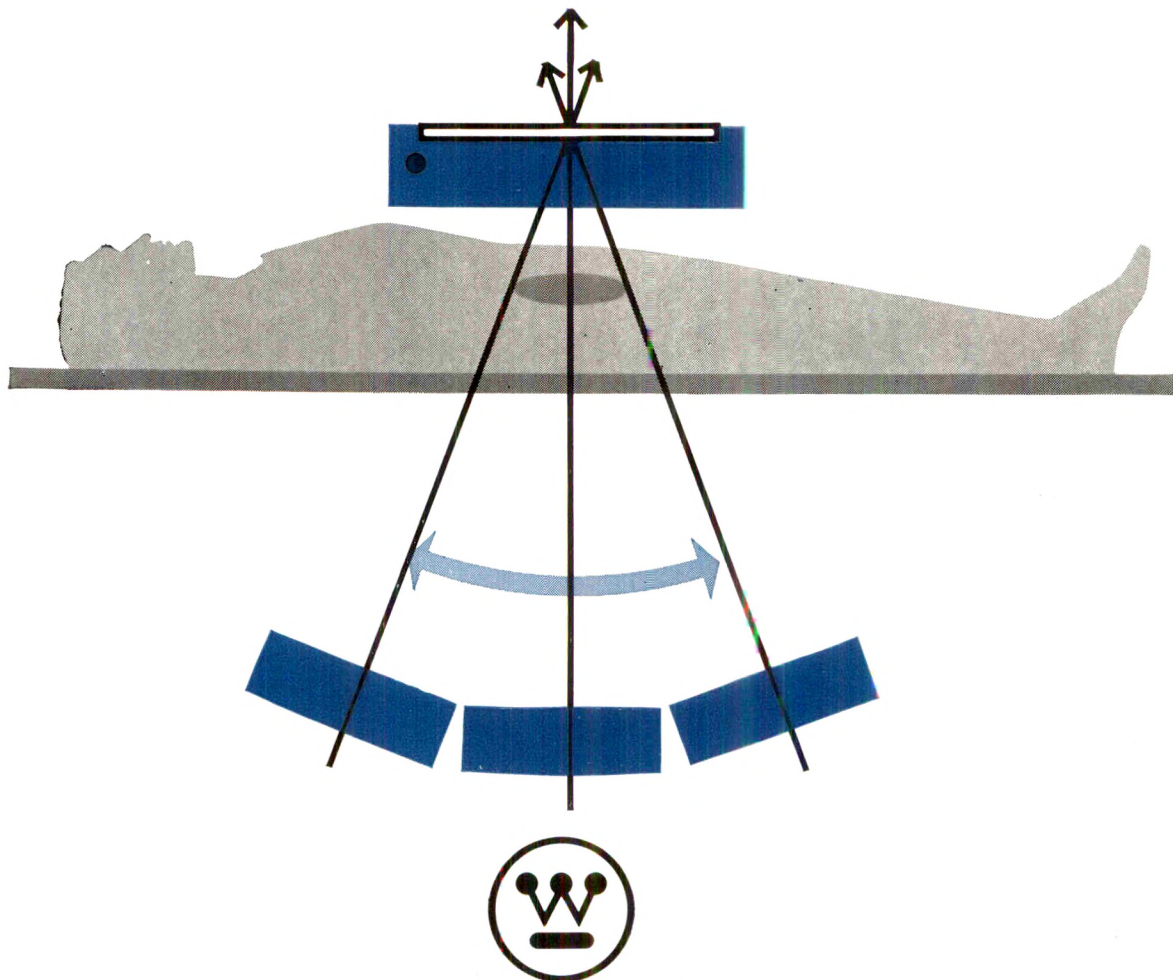
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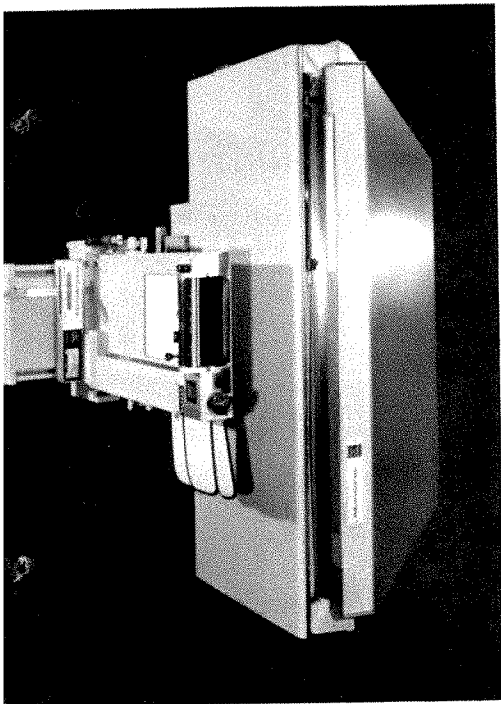
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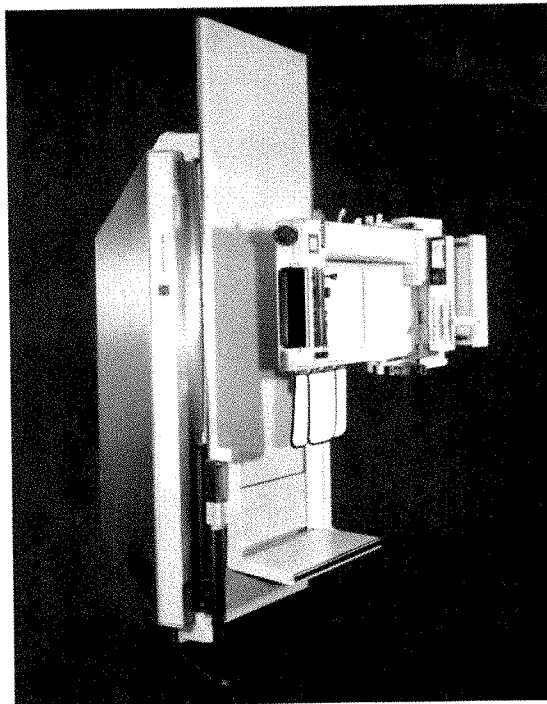
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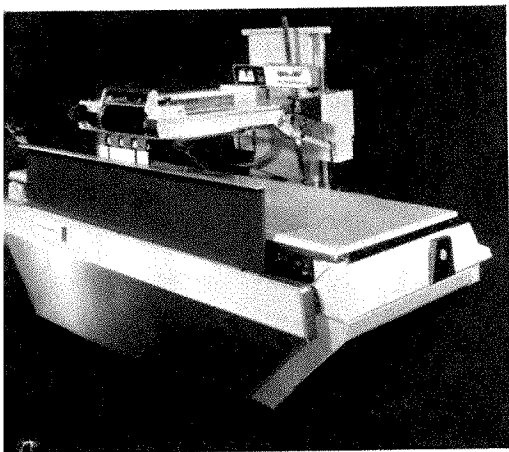
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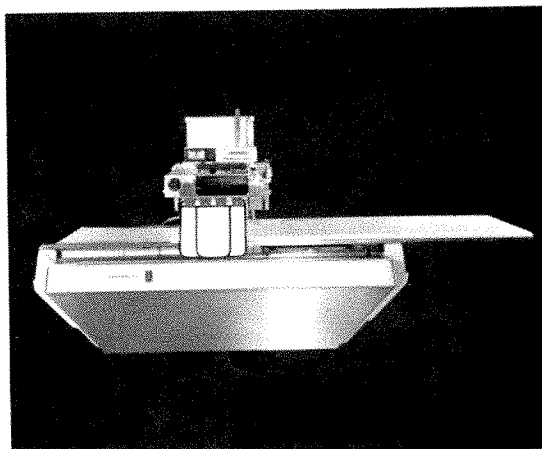
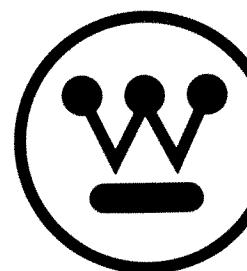


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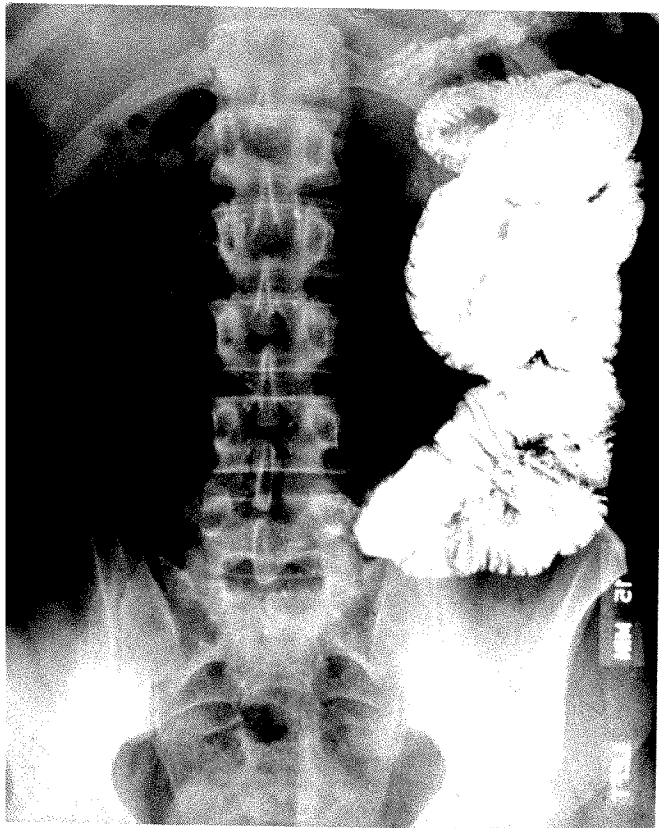


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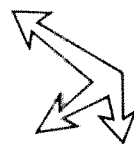
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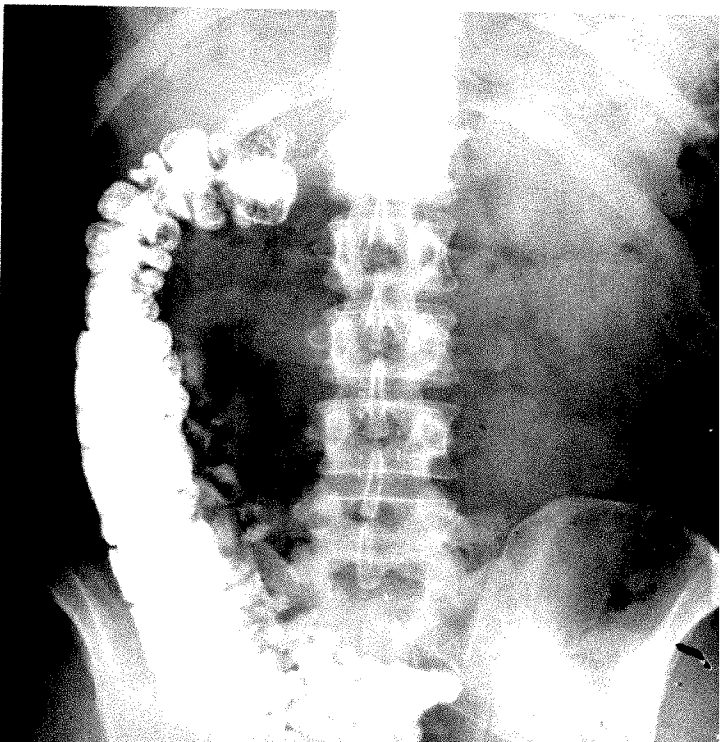
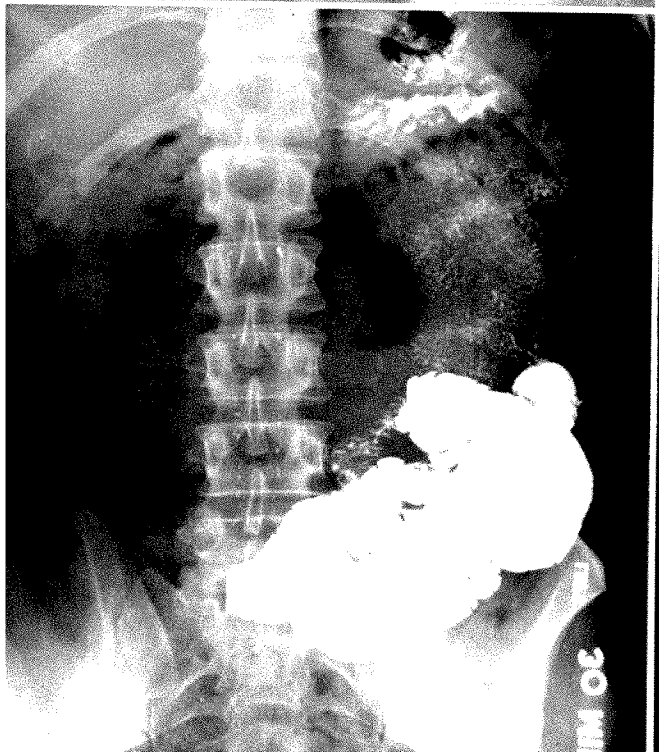
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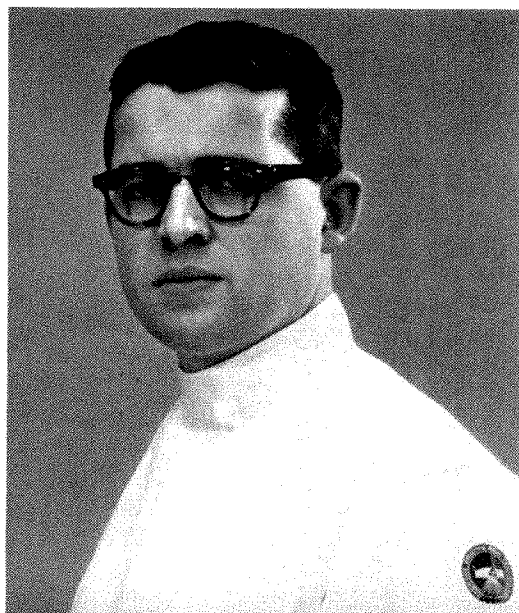
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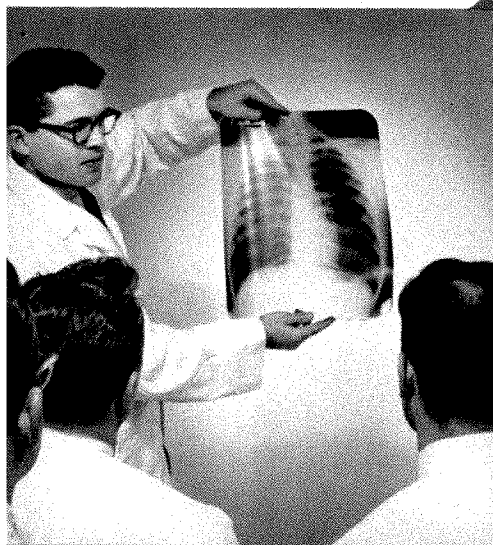
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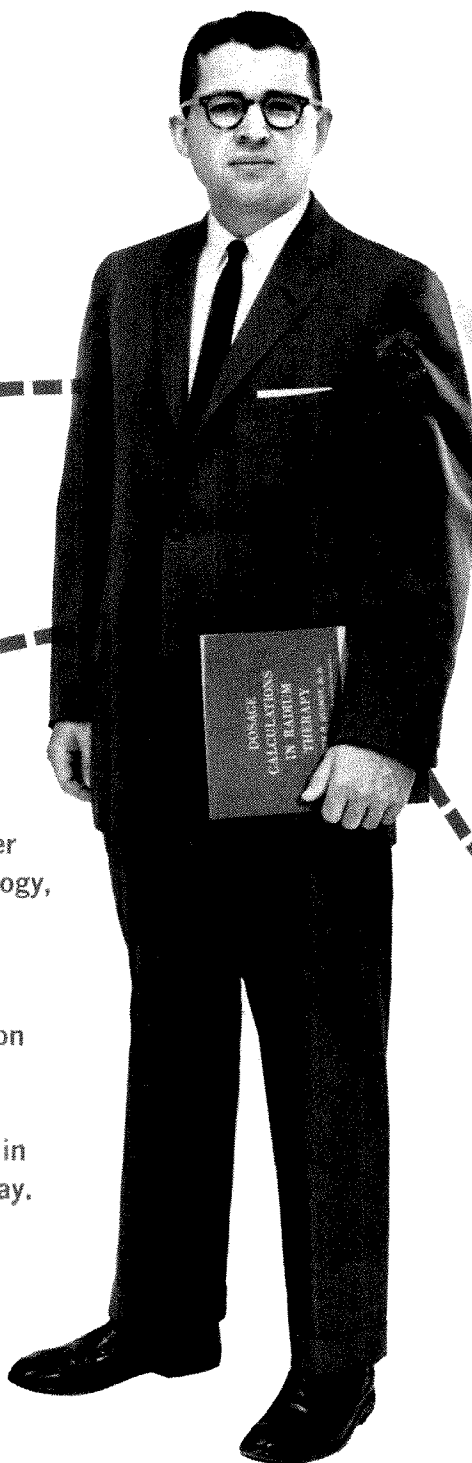


GRADUATE TECHNICIAN

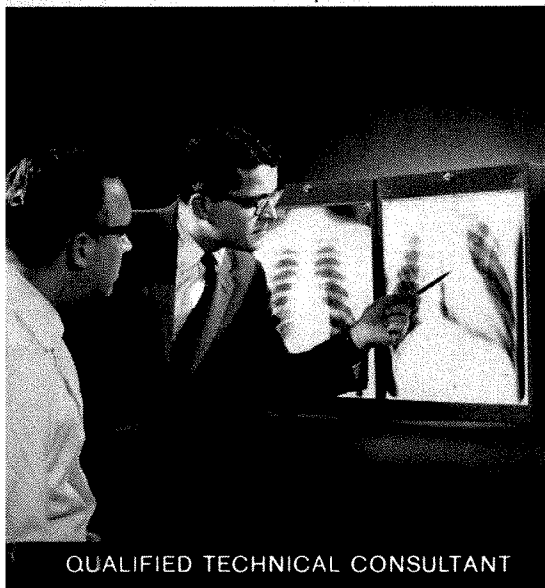


X-RAY TECHNOLOGY INSTRUCTOR

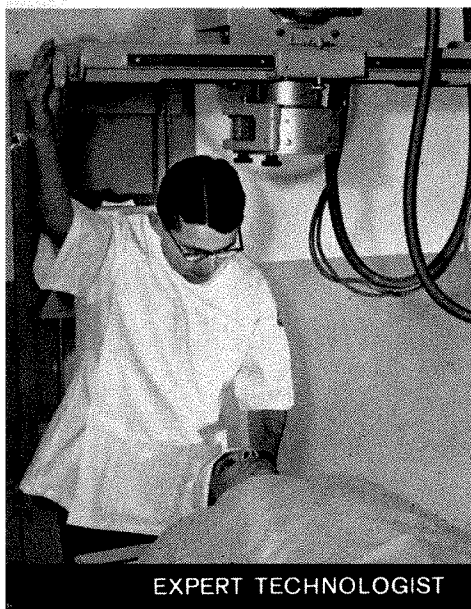
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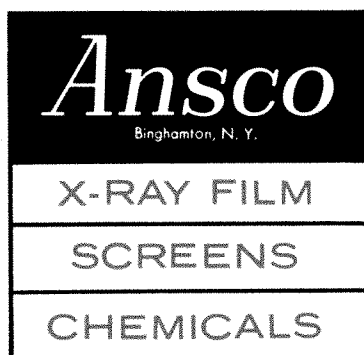
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One example of the features you can select to increase your efficiency is the power-driven "glide-top." It extends a full 30" at each end of the table, dramatically simplifying such procedures as vertical fluoroscopy, angiographic positioning — even the transferring of patients from hospital carts.

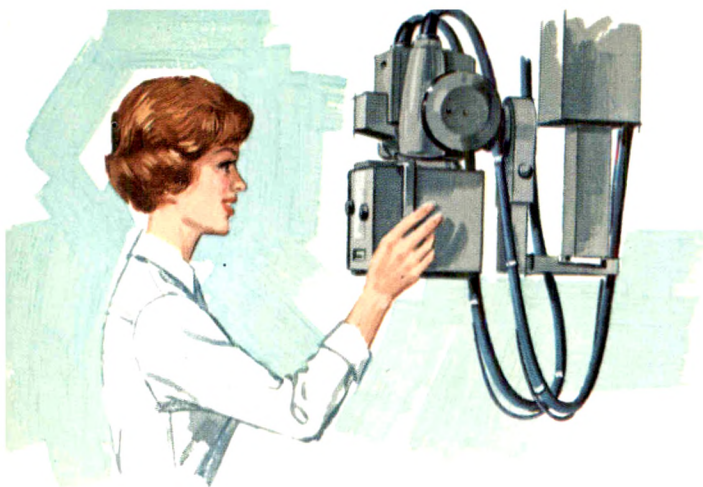
This and other Monarch features are discussed in the following pages. But the proof of Monarch's superiority is in the handling. Contact your General Electric representative. He'll be happy to make arrangements for you to see and try a Monarch in your area.

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LORETTO HOSPITAL, CHICAGO, ILLINOIS

... where a G-E Monarch diagnostic table fills the need for a table that must handle a broad range of radiological applications. "Glide-top" feature is particularly valuable in raising smaller patients to comfortable viewing heights. Patient remains at ease with smooth, steady table-top action.

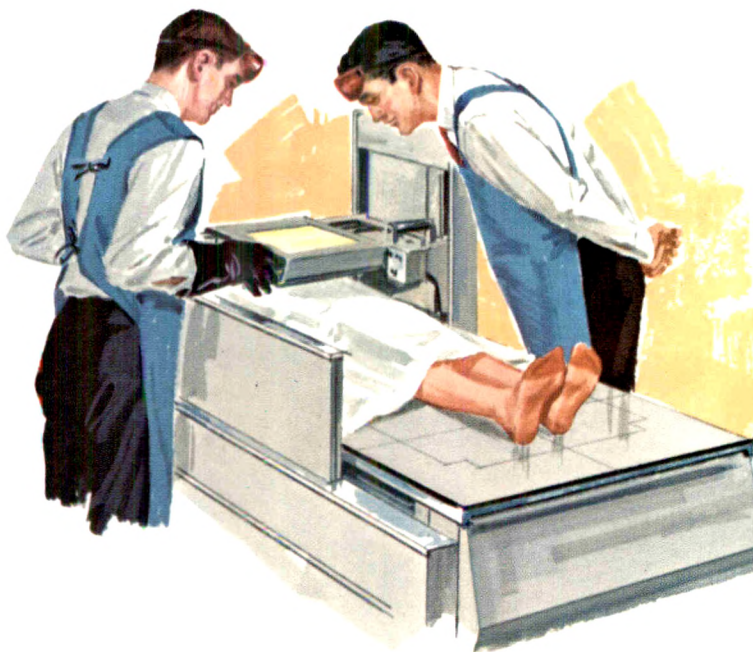


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... for a perfect match with your exact requirements. Two versatile models, offering bilateral overhead travel and full-room coverage. Counter-balanced action provides for smooth handling, easy positioning. Cable systems are designed for interference-free operation.

FULL-CIRCLE ACCESSIBILITY

... makes the Monarch exceptionally versatile and easy to work with. Compact motor-drive housing offers greater convenience for consultation and patient transfer. Combination of fluoroscopic screen travel and electric-powered "glide-top" give you additional patient coverage. Through the full 180° of angulation — from vertical to horizontal stop to 90° Trendelenburg — the table provides a true and convenient "island" facility for both radiologist and consultant.

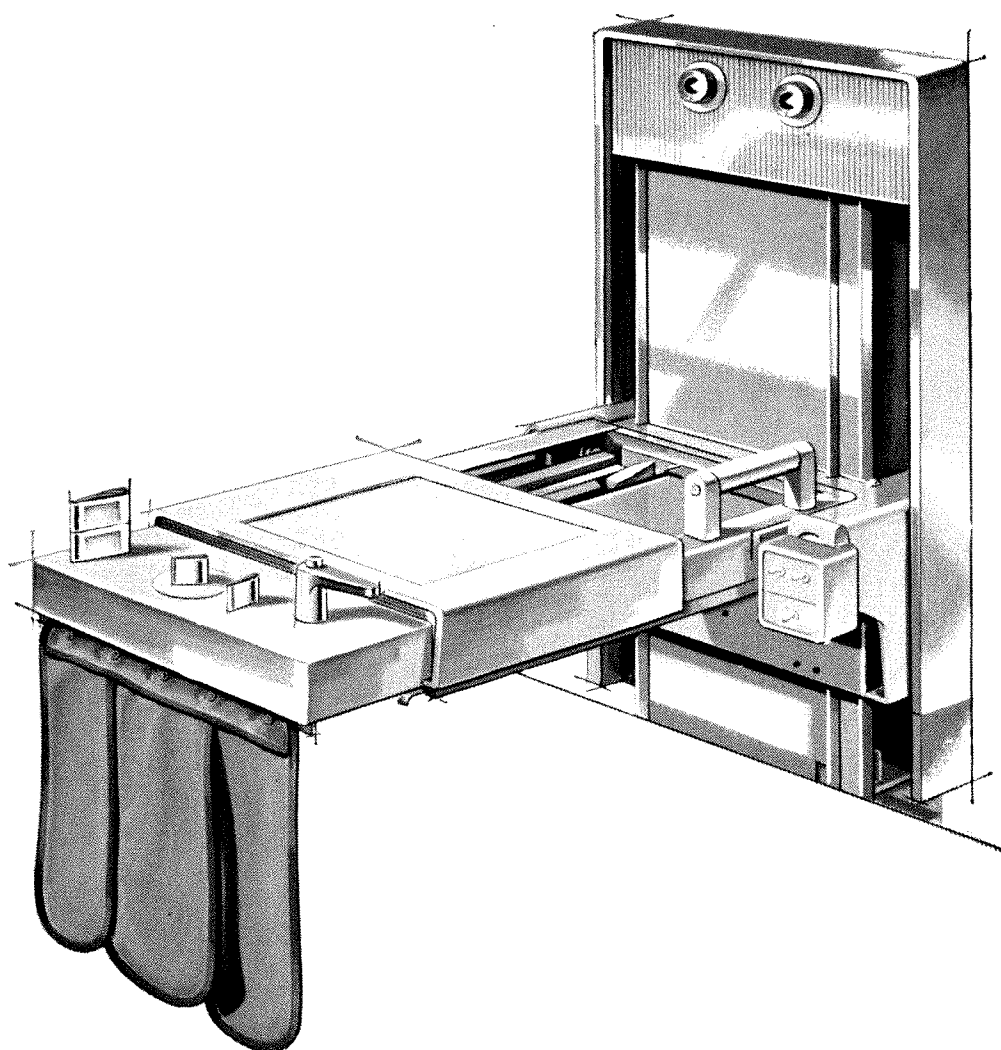


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... supports even the heavy patient with table top extended. The sturdy steel framework of the Monarch gives rigid support ... virtually eliminates vibration caused by other table components to maintain superior results in all your work. A multiple-pivot system and smooth motor action give added stability.



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Monarch offers you a choice of three models for spot-filming and fluoroscopic viewing. All of these superior spot-film devices for the Monarch are precision-engineered, easy-to-handle featherweights. All of them will accept either metal or rubber 8 x 10 and 10 x 12 cassettes. Two models feature optimum phototiming. All three offer a host of other advantages.

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And if the Monarch offers ease for spot-filming, it offers superb control for fluoroscopic viewing. An optional remote kvp control on the

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These are just some of the features that make a Monarch diagnostic x-ray table worth considering. This is the table you can use all day, processing patients on a full appointment schedule, and still not feel physically "worn out." And the Monarch can be tailored to meet your *exact* needs, since many additional features are optionally available. Contact your local G-E representative for more information, or write directly to X-Ray Department, General Electric Co., Milwaukee 1, Wis. Ask for Pub. A-41.

GENERAL  ELECTRIC



the Key

to reduced radiation exposure

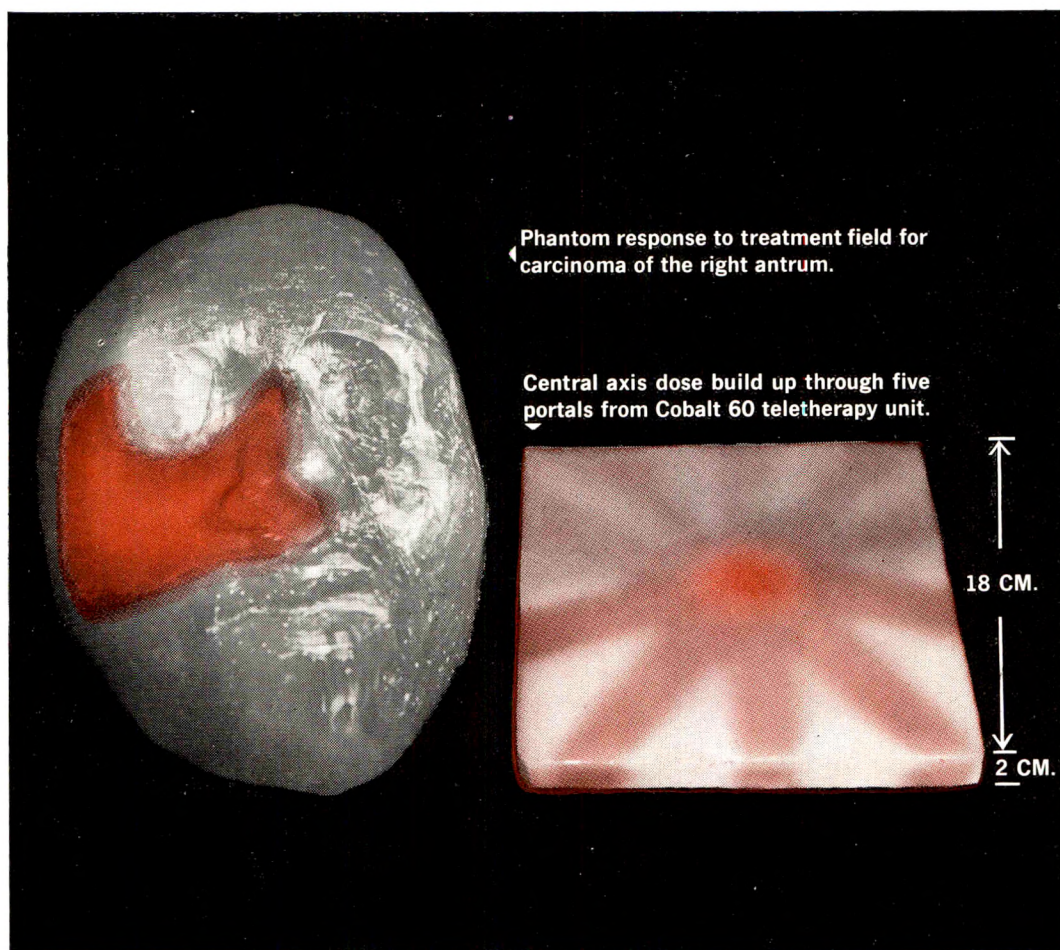
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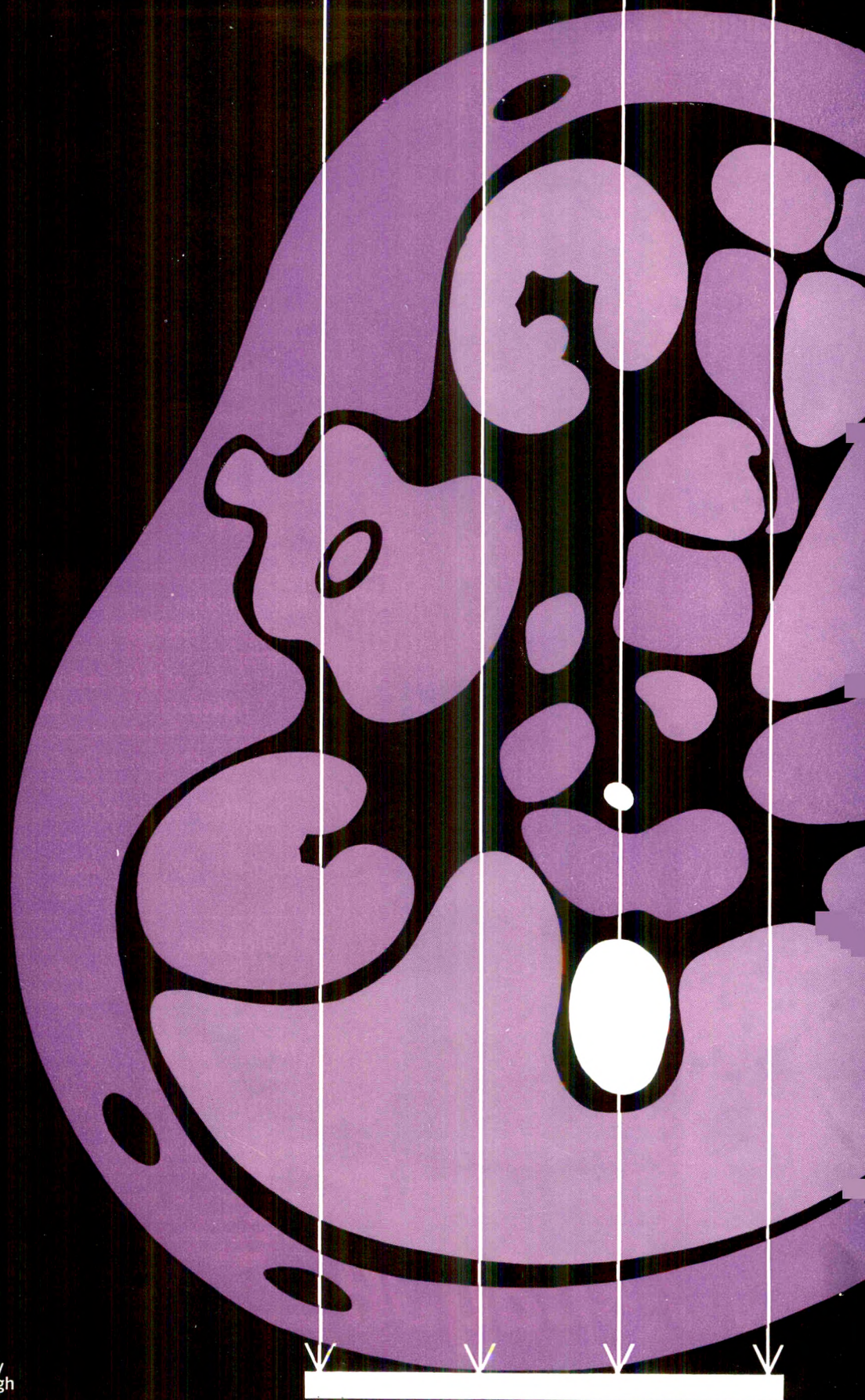


Illustration:
Cross section of body
X-rays passing through
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1. Whitehouse, W. M.: Iopanoic acid, Ann. New York Acad. Sc. 78:809, July 2, 1959. 2. Baker, H. L., Jr., and Hodgson, J. R.: Further studies on the accuracy of oral cholecystography, Radiology 74:239, Feb. 1960.

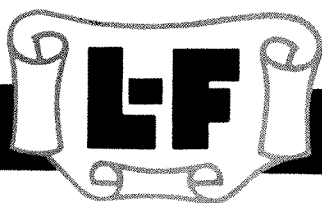
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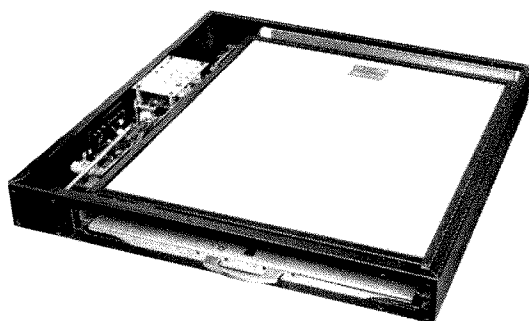
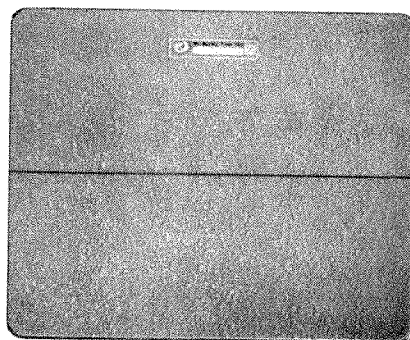
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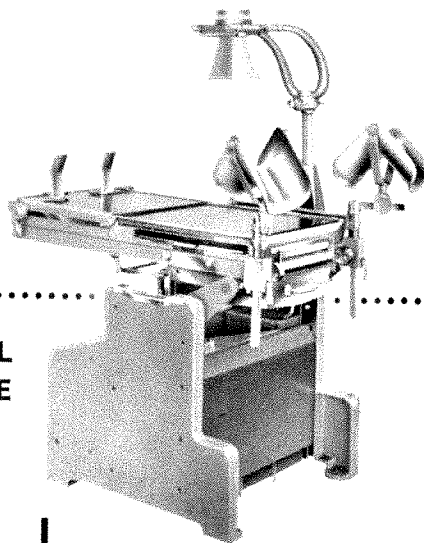


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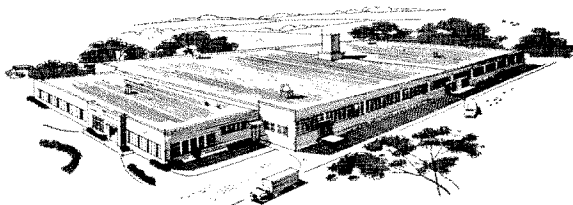
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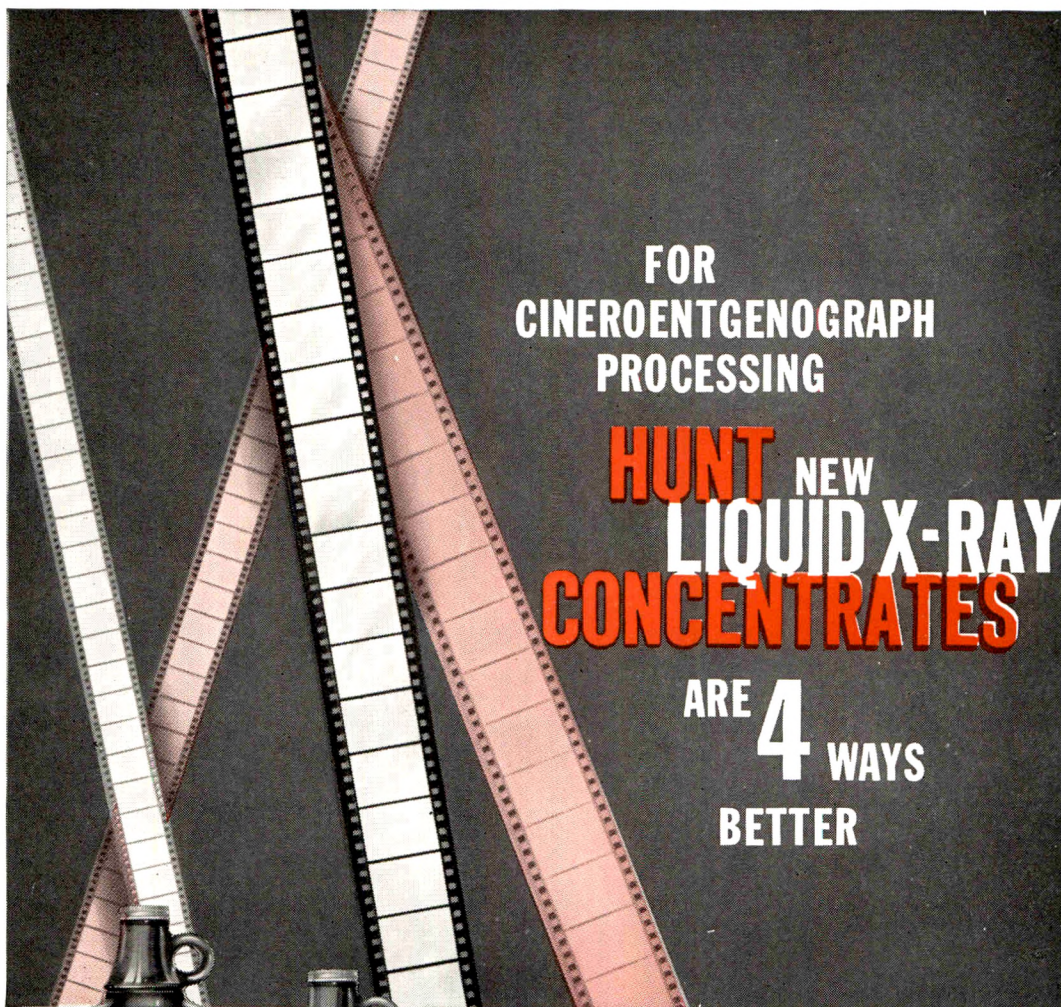


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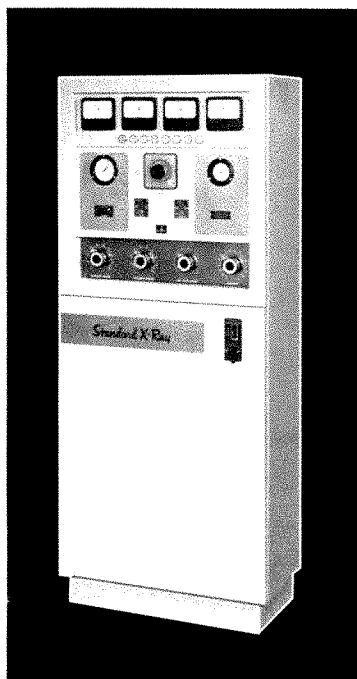
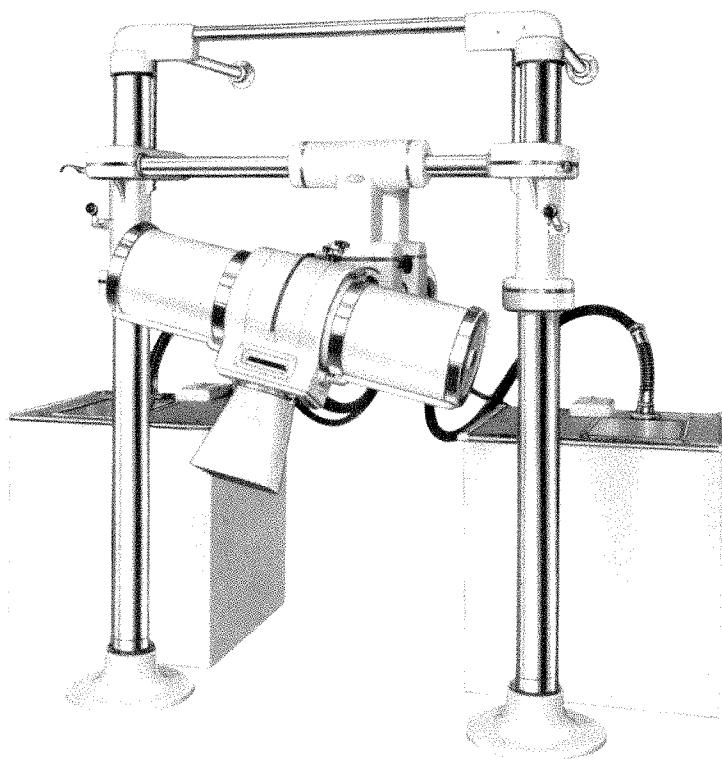
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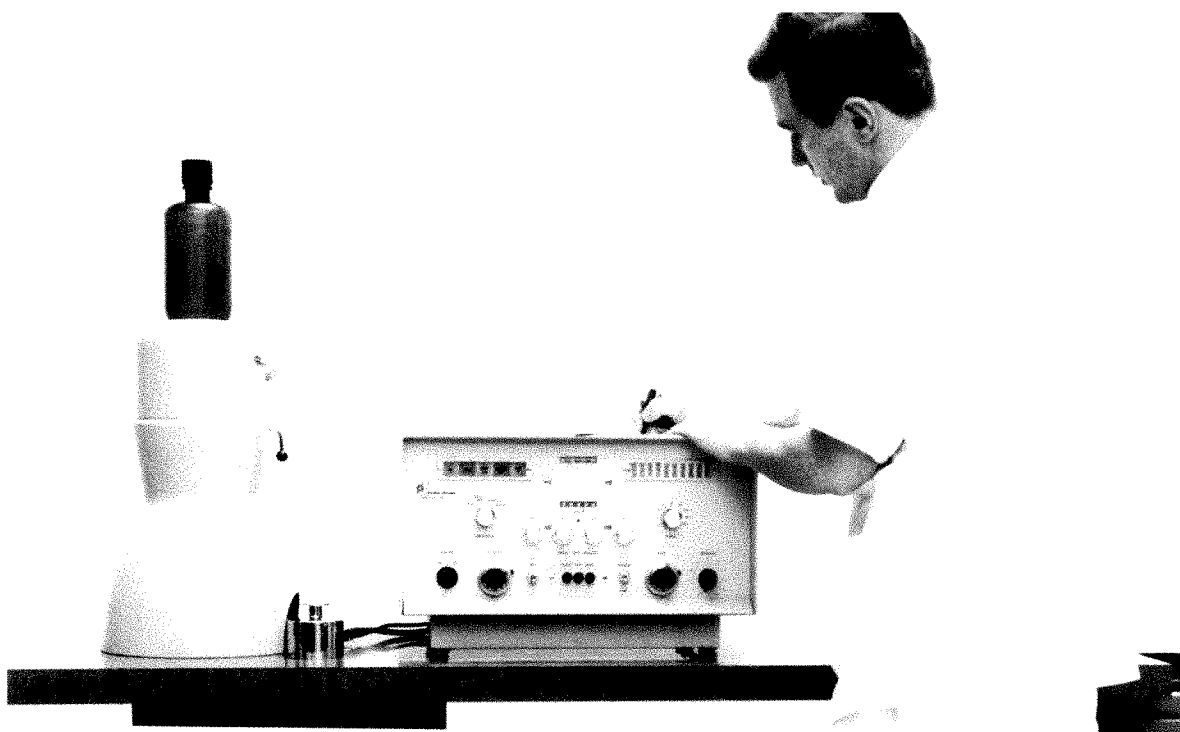
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**DIAGNOSIS OF PERNICIOUS ANEMIA
WITH RADIOCOBALT VITAMIN B₁₂**



Nuclear-Chicago offers a choice of three well scintillation detectors for use in pernicious anemia studies. The DS-202 has a two inch crystal, the DS-302 has a three inch crystal with $2\frac{1}{2}$ " diameter well, and the DS-303 has a three inch

crystal with $1\frac{1}{8}$ " diameter well. Each of these detectors is designed so that the large plastic bottle containing urine can be placed directly on the surface of the crystal. Shown is the DS-202 Well Detector with 132B Scaler/Spectrometer.

DIAGNOSIS OF PERNICIOUS ANEMIA WITH RADIOCOBALT VITAMIN B₁₂

Vitamin B₁₂ is absorbed from the gastrointestinal tract in the presence of an intrinsic factor elaborated by the gastric mucosa. The absorption may be followed after the oral administration of radiocobalt labelled vitamin by estimation of the unabsorbed radioactivity in the feces, by measuring the appearance of radioactivity in the liver which acts as a temporary storage site after absorption, or by the method introduced by Schilling in which the liver uptake is blocked by parenteral administration of a large dose of unlabelled vitamin B₁₂ and collecting the urine for 24 hours. In this case the labelled vitamin absorbed from the intestinal tract is promptly excreted in the urine.

In the patient with pernicious anemia, lack of intrinsic factor prevents normal absorption from the gastrointestinal tract. Following subtotal gastrectomy the absorption of vitamin B₁₂ may be as low as in pernicious anemia. The administration of a dose of potent intrinsic factor prepared from hog's stomach will increase the absorption in subsequent

tests in these two types of patients. In sprue, the absorption of vitamin B₁₂ is low and there is no improvement on administering intrinsic factor.

The amount of vitamin B₁₂ absorbed during the test with the radiocobalt labelled form depends on the weight of the vitamin given. In general there is an increase in the percent absorption as the dose is lowered. With doses of the order of 0.5 micrograms of vitamin B₁₂, the patients with pernicious anemia excrete less than 7 percent of the administered dose in the urine in 24 hours. Administration of a potent intrinsic-factor preparation along with the labelled vitamin will increase the level of urinary excretion to more than 10 percent. Normal individuals excrete more than 10 percent of the administered dose in 24 hours.

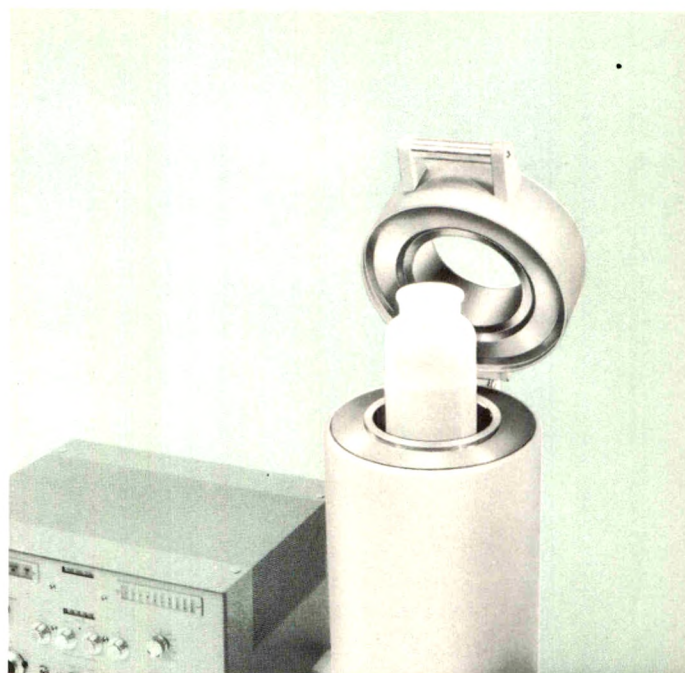
The test is valuable in studies of patients with anemia and neurologic disorders resembling combined cord degeneration. It may be used even during treatment of the patient with vitamin B₁₂ since this will not influence absorption of the vitamin administered orally.

TYPICAL PROCEDURE

1. The patient should be in an overnight fasting state.
2. Administer 0.5 microcuries of Co-60 labelled vitamin B₁₂ by mouth in 30 ml. of solution. Rinse the cup in which the dose was administered several times and have the patient drink the washes.
3. The patient is given 1 milligram of non-radioactive vitamin B₁₂ subcutaneously or intramuscularly within 1 hour after administration of the oral dose.
4. The patient may eat a breakfast of orange juice, toast and coffee 2 hours after the oral B₁₂ is given.
5. The patient is instructed to collect all urine excreted during the 24 hours following the administration of the labelled vitamin.
6. Measure the 24-hour urine volume and transfer one liter to a standard 1-liter polyethylene bottle with a screw cap. If the 24-hour volume is less than 1 liter, dilute to 1 liter before transferring to the bottle.
7. Position the bottle on the crystal of a well scintillation detector, and count.
8. Measure a second sample of the Co-60 labelled B₁₂ administered to the patient into a liter volumetric flask and dilute to 1 liter with water. Measure 100 ml. of the diluted standard into a second standard polyethylene screw-cap bottle and dilute to 1 liter with water. This represents 10 percent of the dose administered diluted to the standard volume of 1 liter.
9. Position the standard on a crystal of the well scintillation detector and measure the activity.
10. Measure background with a water-filled polyethylene bottle positioned on the top of the well detector.
11. Calculate the percent excretion by the formula:

$$\text{Excretion (in \%)} = \frac{U \times 10 \text{ (cpm in urine - background)}}{\text{cpm in standard - background}}$$

where U =
liters of urine collected in 24 hours



Excellent geometry and high sensitivity is provided by the DS-303 Well Scintillation Detector. The polyethylene bottle rests directly on the 3" well crystal. Model 132B Scaler/Spectrometer is used with the well detector. Additional shielding can be obtained by closing the lid of the detector. Bottles up to 5½" diameter can be inserted and removed without raising the lid.

RESULTS

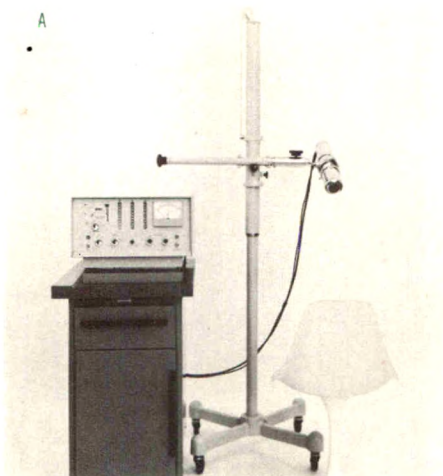
Normal individuals excrete more than 10 percent of the administered dose of radioactivity in the urine in 24 hours. In pernicious anemia and sprue, the urinary excretion is less than 7 percent. Administration of a potent intrinsic factor in subsequent tests increases the excretion in the pernicious anemia patient to normal. There is little effect in excretion in sprue.

In severely impaired kidney function the excretion may be sufficiently reduced to invalidate the test.

REFERENCES

1. R. L. Huff, et al, *J. Clin. Invest.* 29: 1041 (1950) and 30: 1514 (1951).
2. L. Saylor, & C. A. Finch, *Am. J. Physiol.* 172: 372 (1953).
3. R. F. Schilling, D. V. Clatanoff and D. R. Korst, *J. Lab. Clin. Med.* 45: 926-934 (1955).
4. J. R. Krevans, C. L. Conley and M. V. Sachs, *J. Chronic. Dis.* 3: 234-252 (1956).

NUCLEAR-CHICAGO SYSTEMS FOR IN-VIVO NUCLEAR MEDICINE



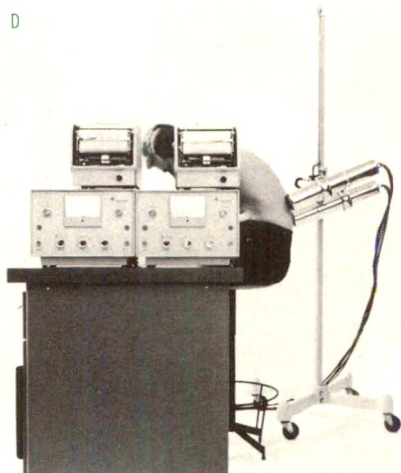
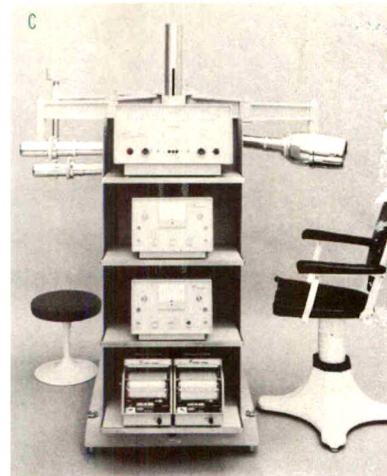
Nuclear-Chicago's extensive line enables the clinician to choose a system specifically designed to meet his needs and budget. Shown above are three complete systems for thyroid uptake measurements and similar applications.

Photograph A illustrates a basic system which combines the 181B Decade Scaler, DS-101 Scintillation Detector, and the SA1 Detector Stand. A second arm and detector can be added to the stand for conversion to kidney function studies as in photograph D.



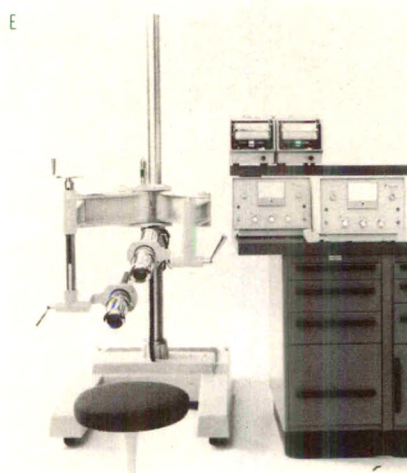
A more versatile single-detector system is shown in photograph B. Here the DS-201 two inch crystal Detector is mounted on the SA2 Detector Stand which provides a shelf for the 132B Scaler/Spectrometer or other clinical scaler.

Nuclear-Chicago's most versatile *in-vivo* system (C) includes the DS-301 three inch crystal Detector and 132B Scaler/Spectrometer for thyroid uptake measurements. Two additional arms and probe detectors, two ratemeters, and two recorders are provided for kidney function studies.



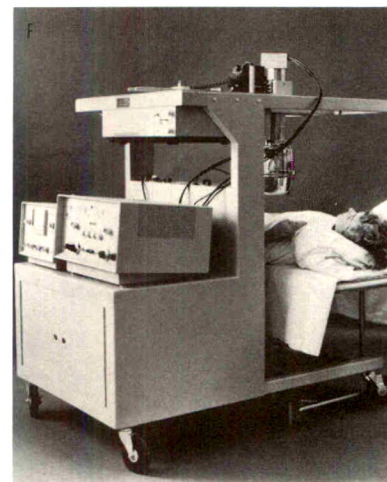
Nuclear-Chicago's basic kidney function system is shown in photograph D. It consists of two DS-101 Detectors, two 1620BS Ratemeters, two R1000A Chart Recorders, and the SA1 Stand equipped with a second arm. A more versatile system is shown in photograph E. Here the 1710 Stand is used instead of the SA1. A motor in the center column automatically raises or lowers the arms to the desired position. This system can be expanded as the needs of the laboratory increase. An instrument rack and third arm can be added as shown in photograph C.

Nuclear-Chicago offers the most advanced system commercially available for scanning body areas for radioisotope concentrations. The 1705 Dual Scanner shown in photograph F with the DS-301 Scintillation Detector and 132B Scaler/



Spectrometer provides both printed and photographic records of the distribution of radioisotopes in body organs. The 1705 has been successfully used in brain, kidney, thyroid, and liver scanning. The system can be used in thyroid uptake measurements by merely changing collimators.

Complete descriptions of instruments shown here can be obtained by writing for General Catalog S.



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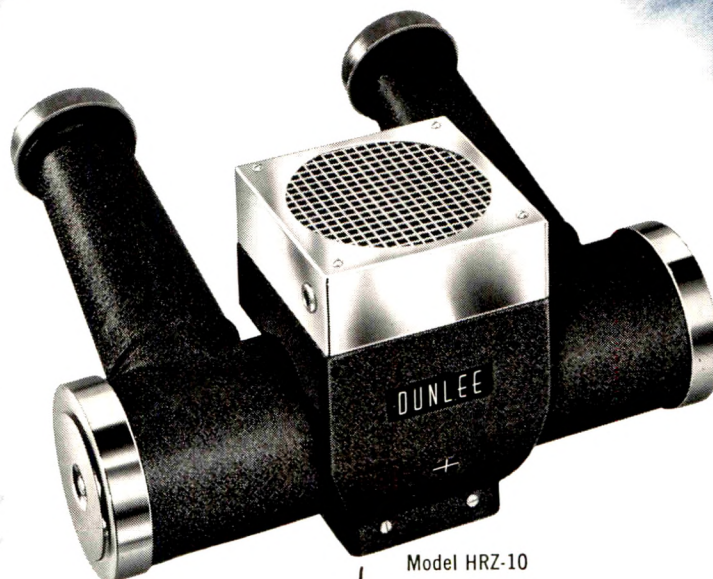
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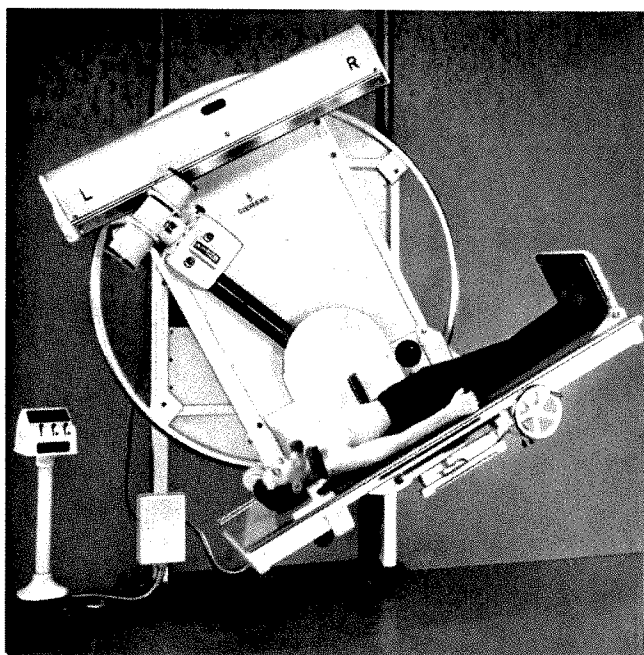
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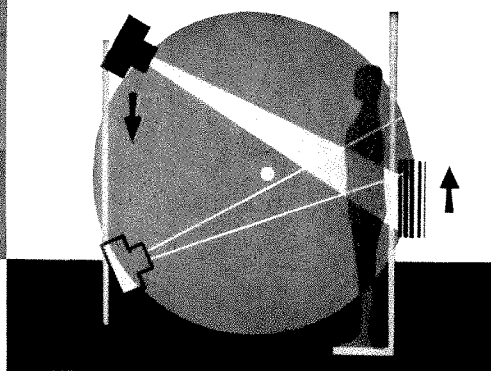
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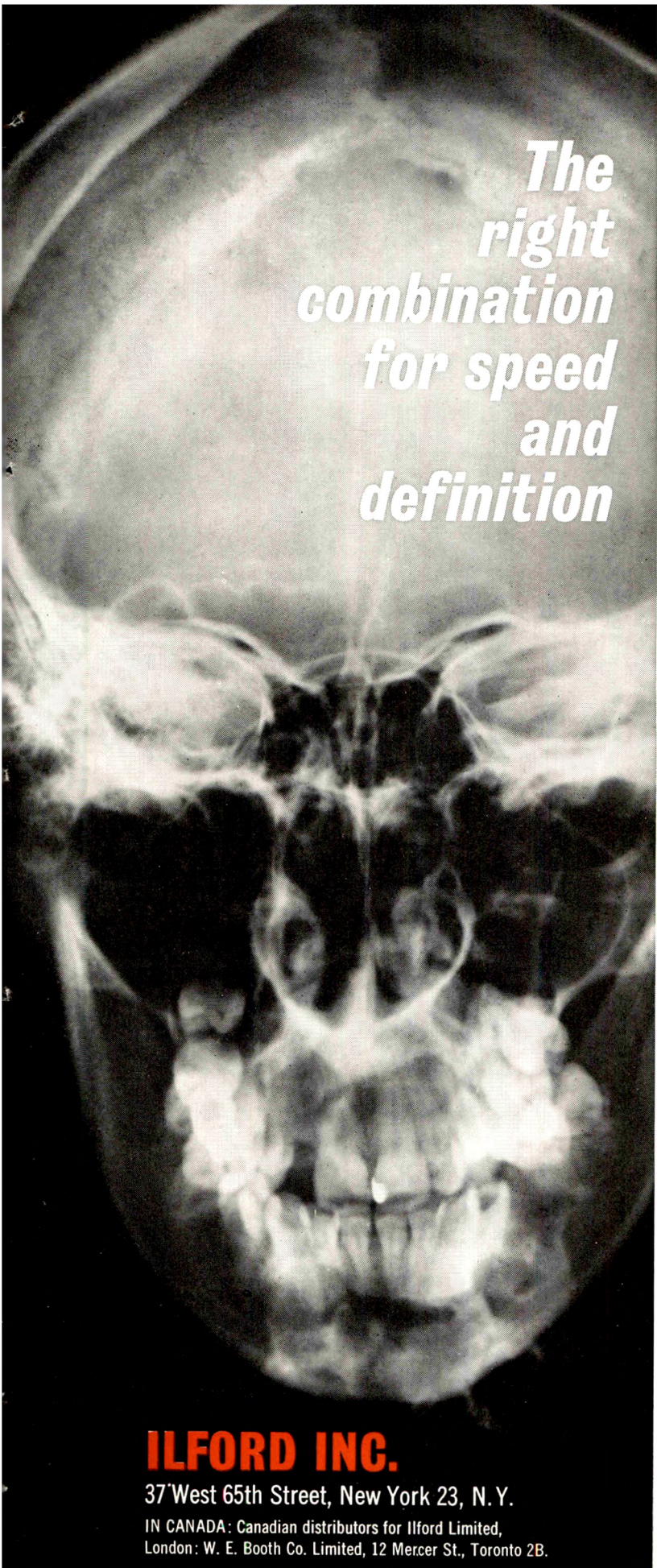
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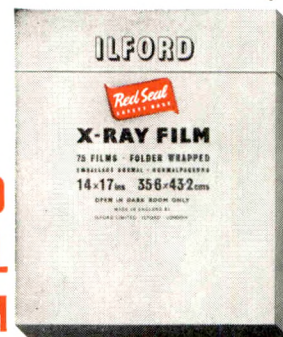
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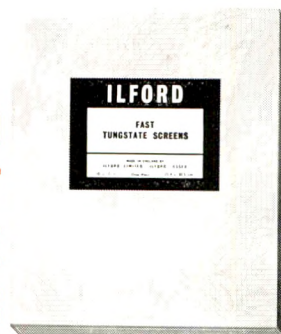
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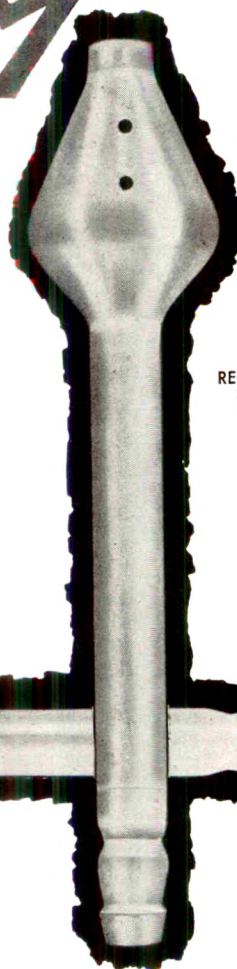
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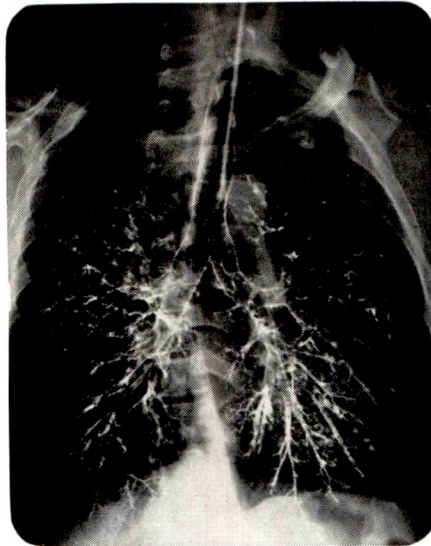
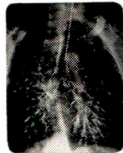
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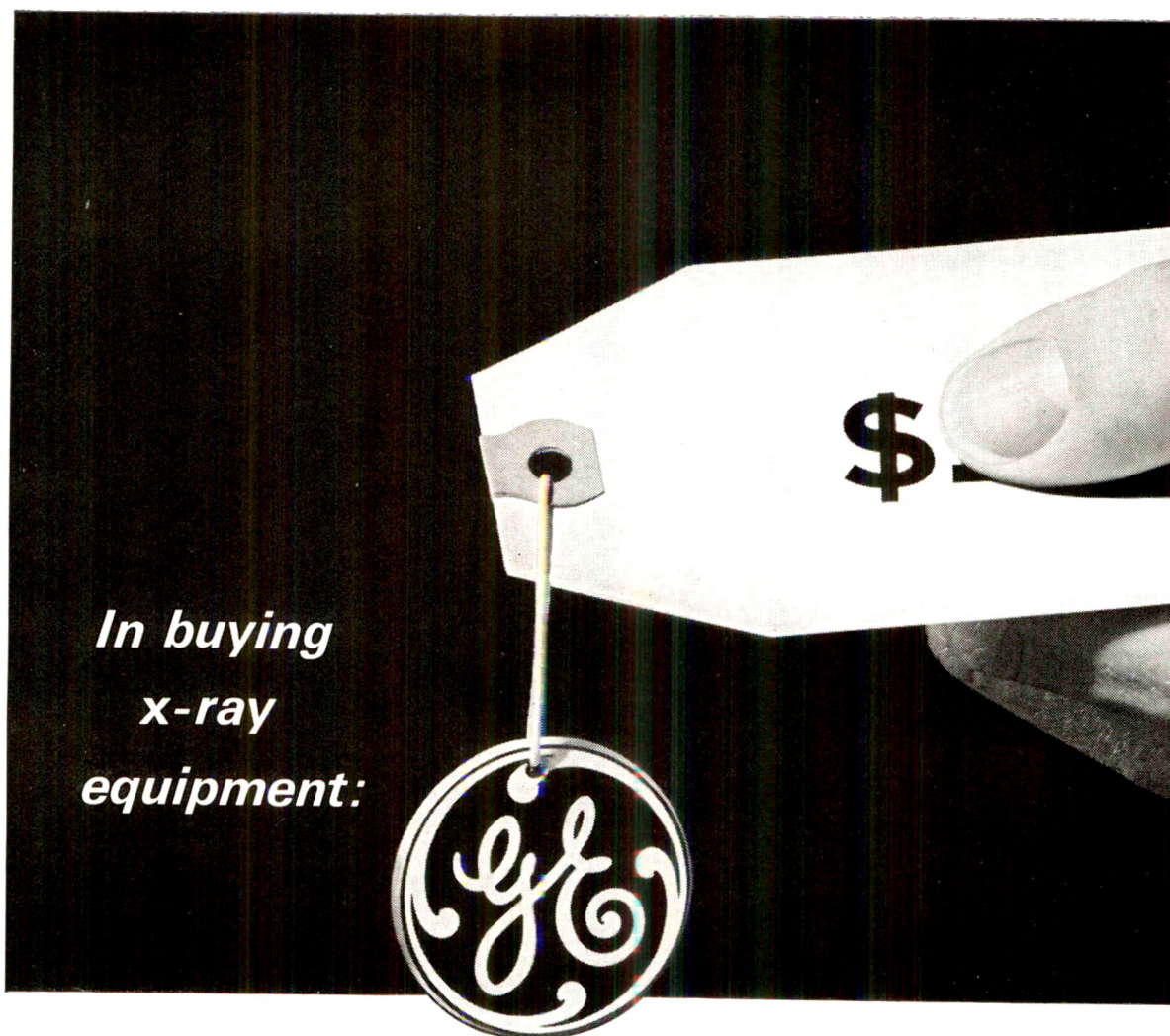
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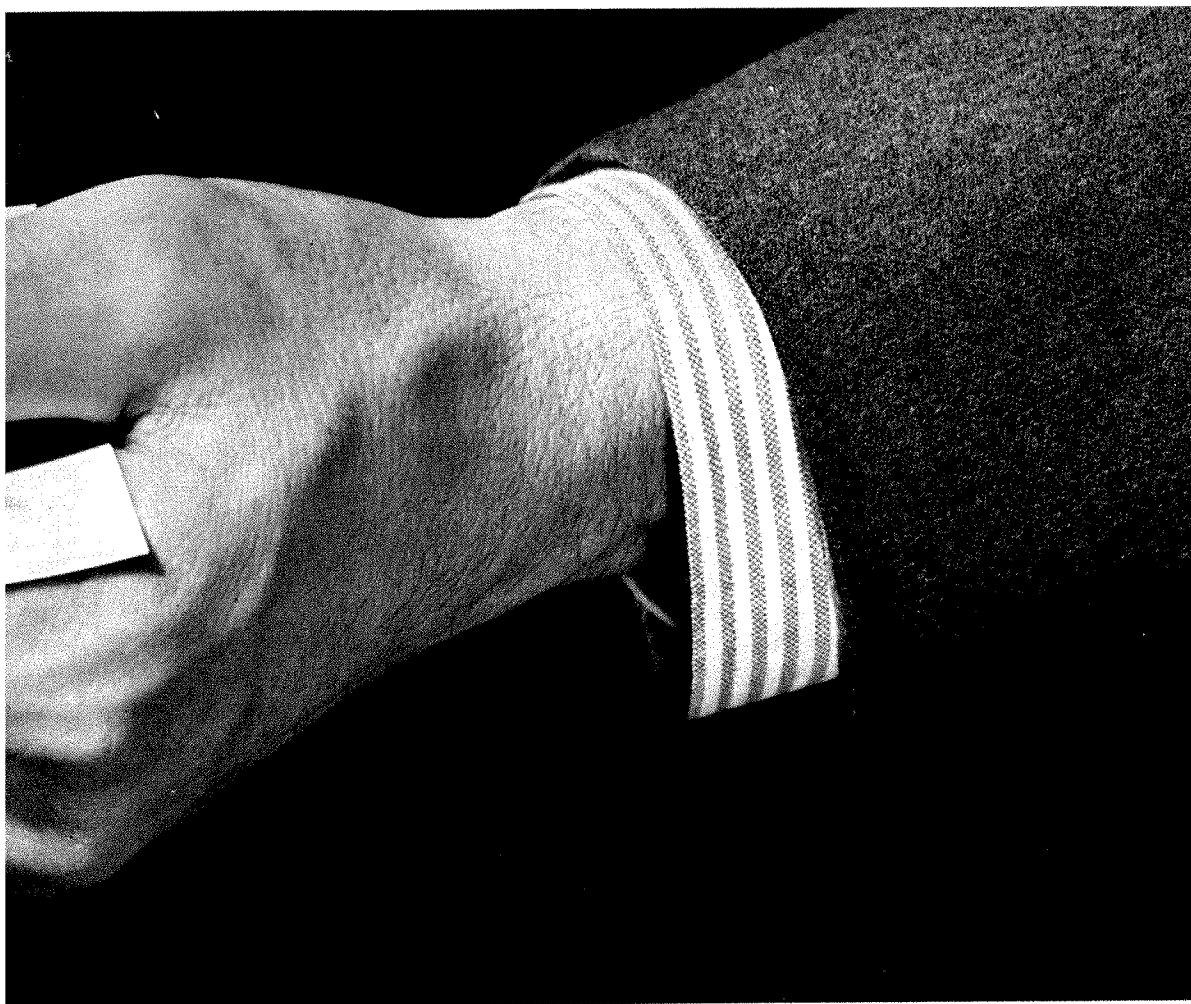
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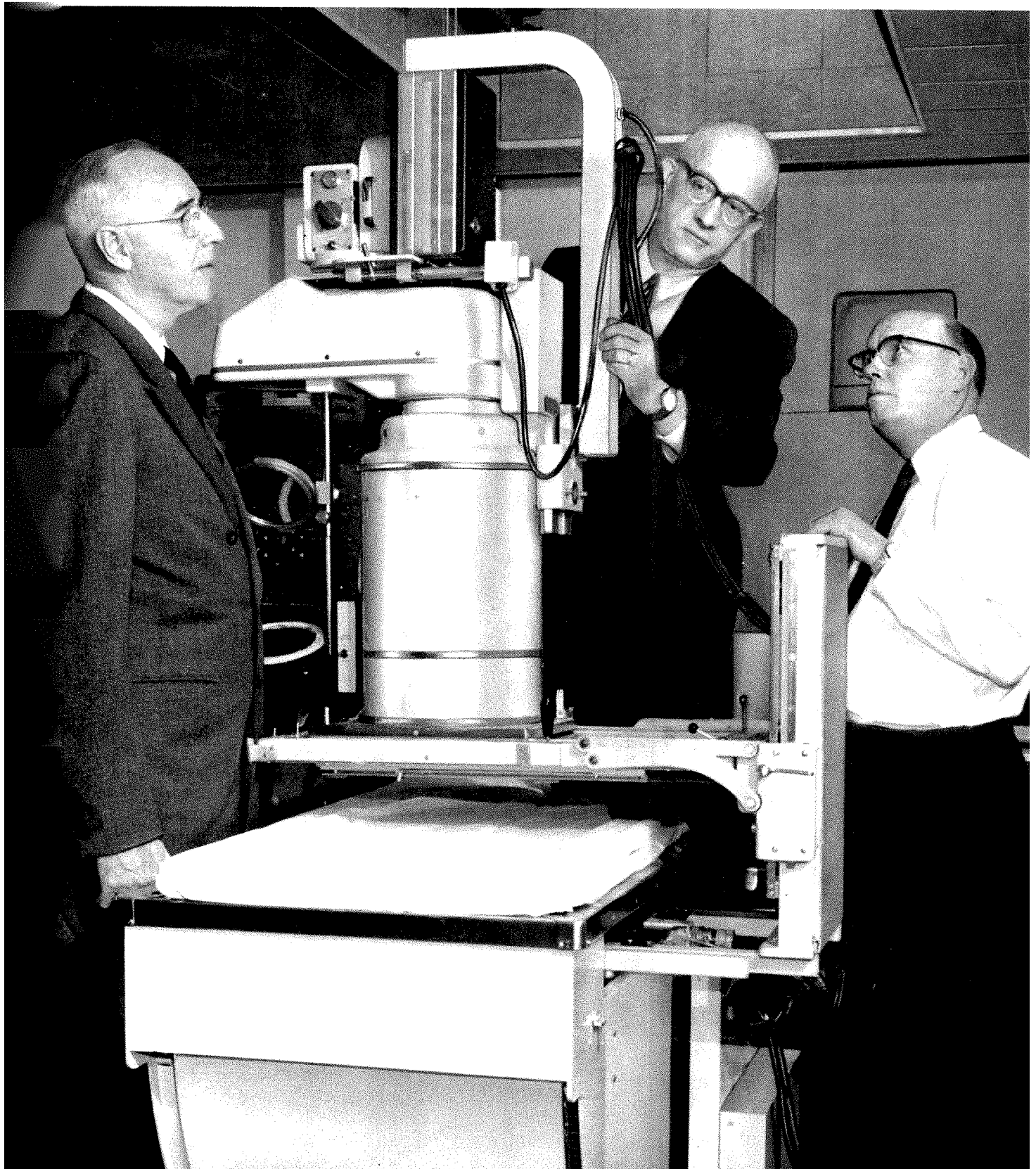
point it also seems pertinent to observe that General Electric *outsells* other x-ray equipment... *a pretty good testimonial to the value!*

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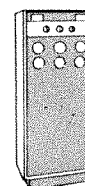
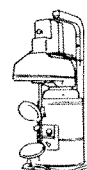
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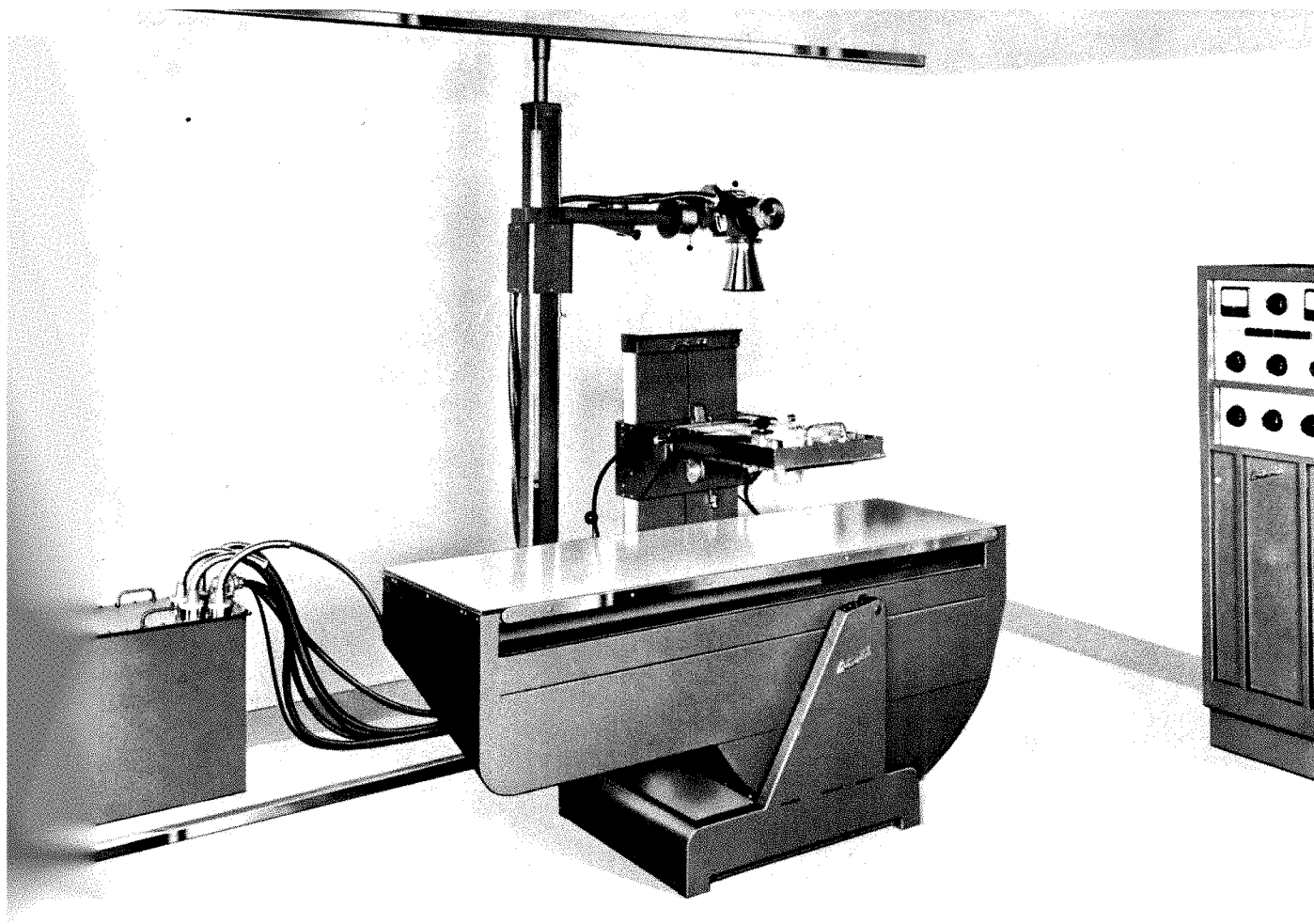
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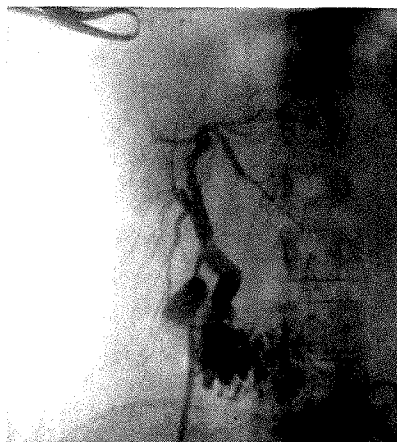
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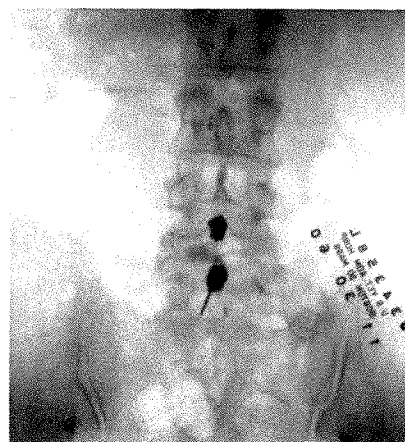
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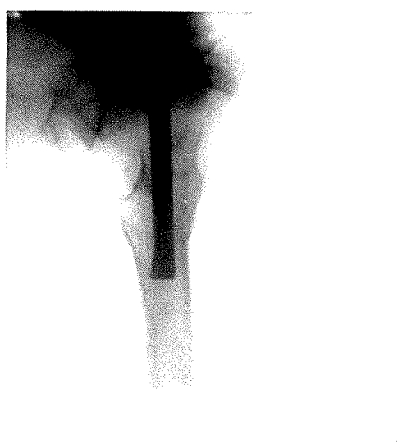
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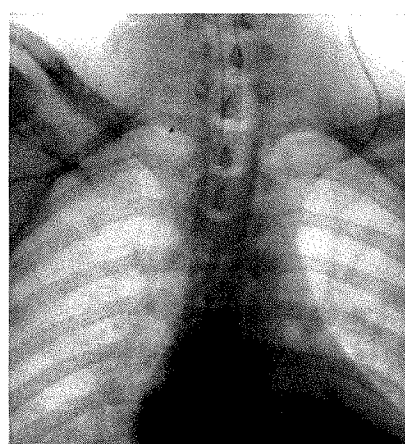
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Publication date October 1961

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GEORGE TIEVSKY, M.D.

*Clinical Instructor in Radiology
George Washington University
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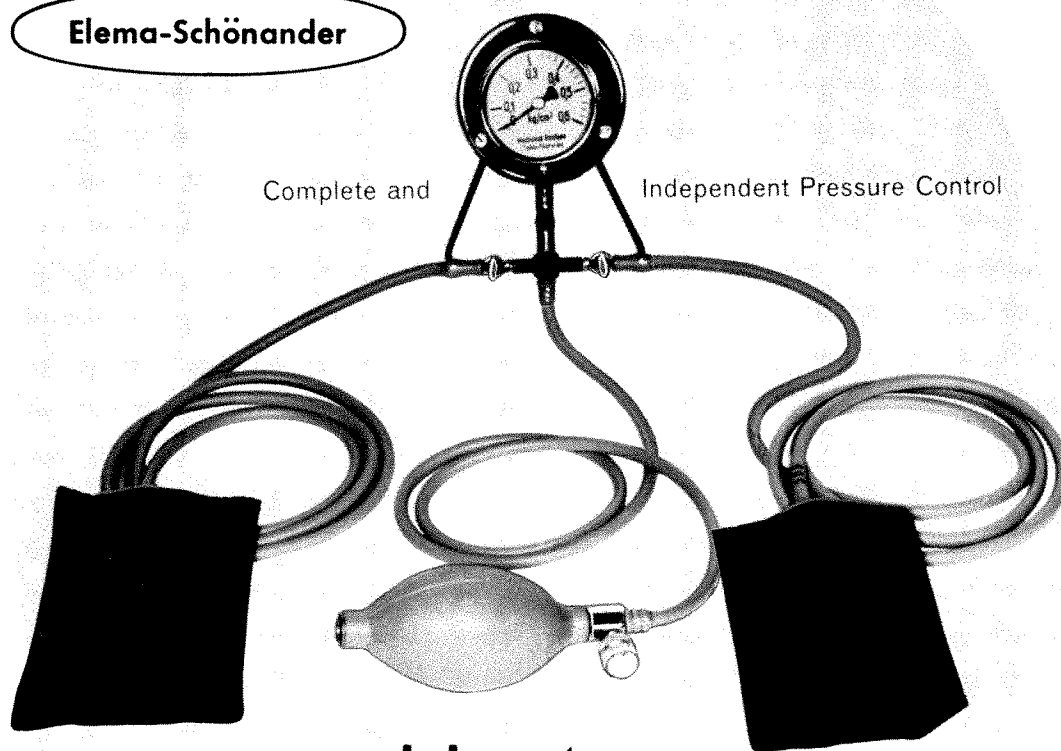
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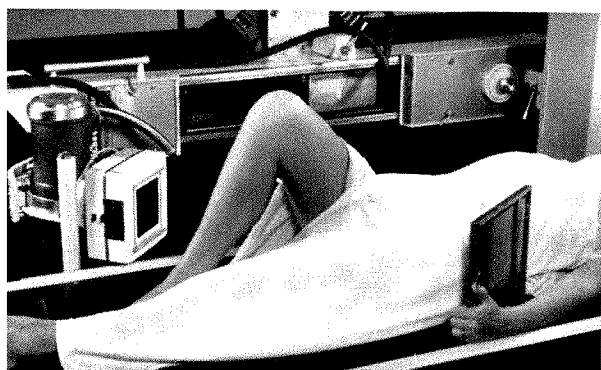
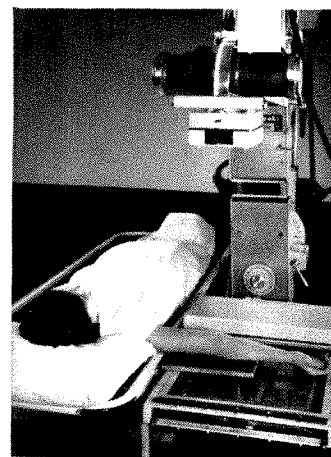
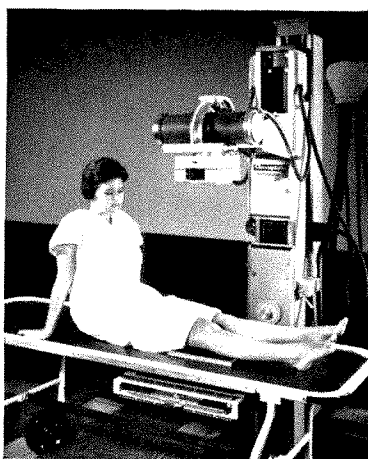
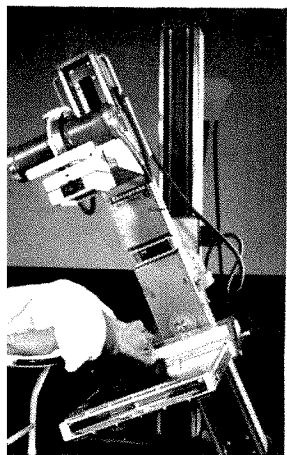
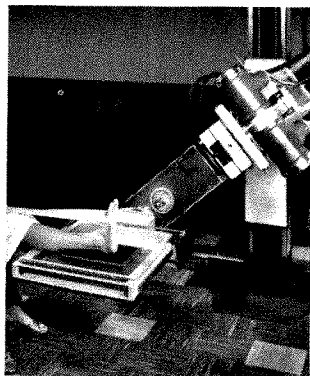
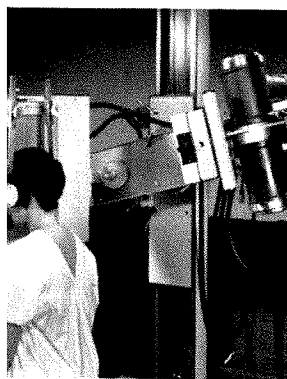
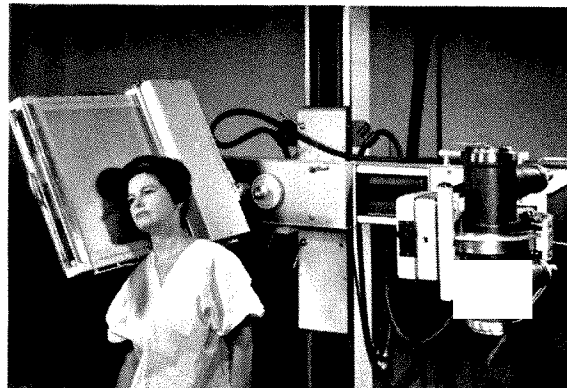
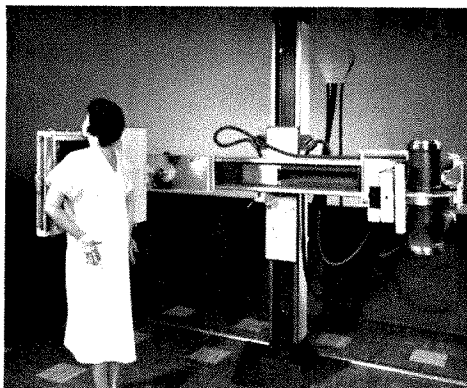
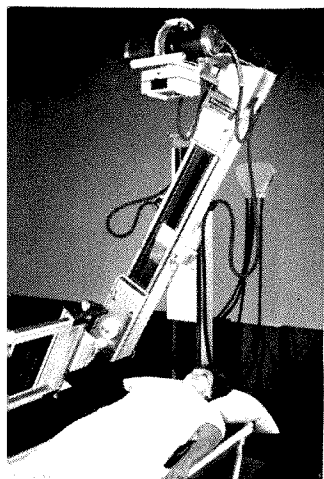
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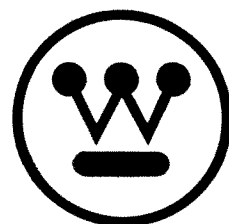
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RADIUM THERAPY AND NUCLEAR MEDICINE

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APRIL, 1962

No. 4

THE USE OF SILICONE FOAM FOR EXAMINING THE HUMAN SIGMOID COLON*

By GALEN B. COOK, M.D., and ALEXANDER R. MARGULIS, M.D.†
ST. LOUIS, MISSOURI

DISEASES of the sigmoid colon are difficult to diagnose when situated beyond the range of the sigmoidoscope or when masked by superimposed bowel loops that cannot be separated roentgenographically or fluoroscopically. For these reasons, roentgenologists have devised the double contrast enema, the use of diluted barium suspension and high-voltage technique, the application of external bag compression and urinary bladder filling and the Chassard-Lapine, cephalad-prone, and supine-oblique projections. However, in spite of the effectiveness of these techniques in detecting large lesions, they are frequently unreliable when small abnormalities are sought. This presentation concerns a new method specifically designed to clarify the character of sigmoid colon lesions which are otherwise indefinitely recognized or totally undiscerned (Fig. 1-11, inclusive).

The persons selected for this study had roentgenographic or sigmoidoscopic findings suggestive or diagnostic of disease.

Each then received an enema of radiopaque silicone elastomers introduced under fluoroscopic control. A catalyst made the liquid polymerize within the lower colon in less than five minutes to form a soft, foamed mold which assumed the contour of the bowel and gave an accurate imprint of its mucosa. The mold was expelled and its surface inspected for irregularities. Adherent cells were washed free and examined microscopically. The technique is similar to that described earlier for surgical specimens and animals.^{1,2}

COMPOSITION OF THE ENEMA

The enema was a mixture of the following:

*Silastic RTV 502**—a silicone rubber that is the basic structural component of the polymerized mold giving it strength and a surface capable of recording minute details. The molecule of this elastomer is a

* Dow Corning Corporation, Midland, Michigan.

* From the Department of Surgery, and the Edward Mallinckrodt Institute of Radiology,† Washington University School of Medicine.

Presented at the Sixty-second Annual Meeting of the American Roentgen Ray Society, Miami Beach, Florida, September 26-29, 1961.

Supported in part by a Grant-in-aid from Baxter Laboratories, Morton Grove, Illinois.

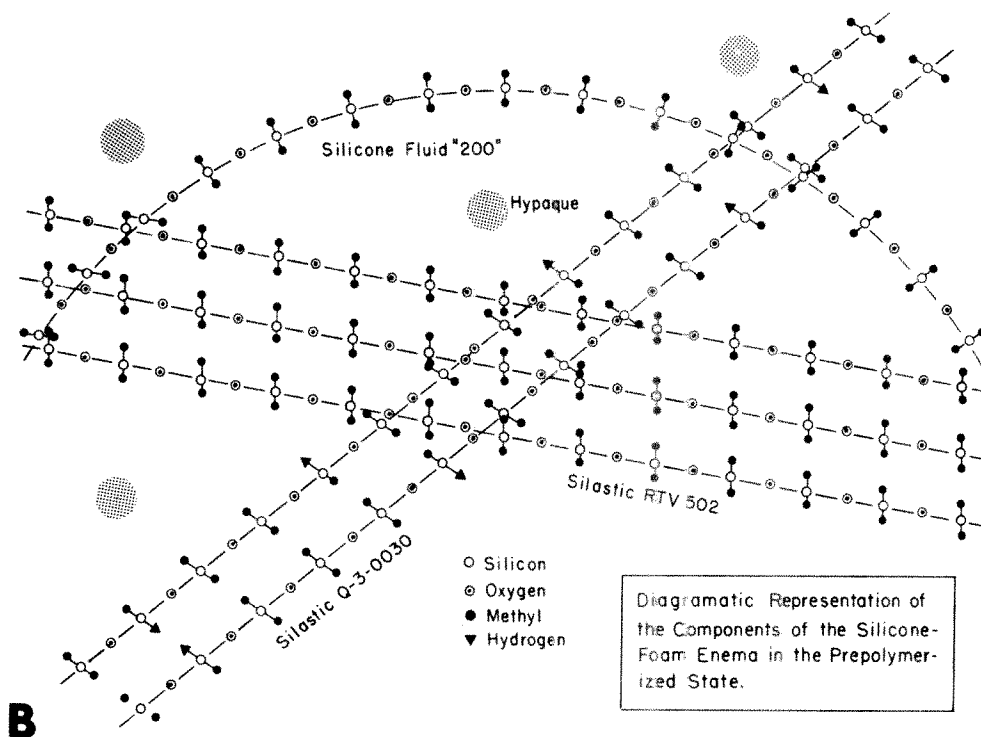
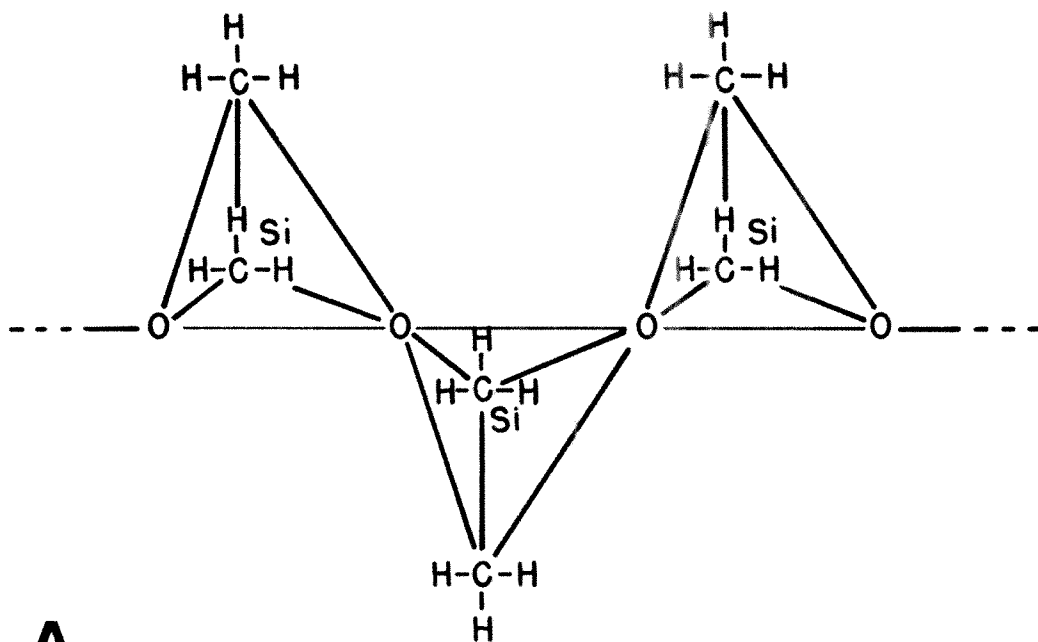


FIG. 1. (A) Schematic drawing of part of a silicone chain. The silicon atom is represented as a tetrahedron with two of its valences filled with methyl groups and two filled with oxygen atoms. The heavy lines do not represent chemical bonds but are used to imply three dimensions. The straight chain is formed by several thousand such units with silicon and oxygen atoms alternating and short aliphatic radicals (mostly methyl groups) forming side chains. Only three such monomers are depicted here. (B) Schematic composite drawing of the silicone foam enema mixture. Crosslinking of the Silastic RTV 502 chains as well as of the Silastic Q-3-0030 chains occurs during polymerization at intervals of several hundred units. The Silicone 200 fluid molecule does not polymerize.

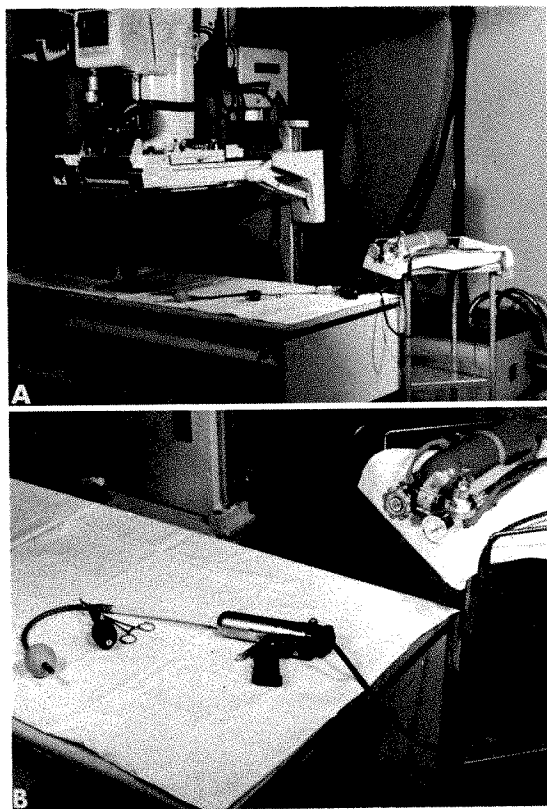


FIG. 2. (A) A photograph of the equipment presently used in performing the silicone foam enema study. The compressed air tank of the industrial sealant gun is placed on the side table. The disposable plastic cartridge filled with the silicone foam enema mixture is attached to the Foley catheter. (B) Closeup of the equipment described.

straight chain of several thousand alternate silicon and oxygen atoms with side branches of short aliphatic radicals (predominantly methyl groups) (Fig. 1A).

*Silastic Q-3-0030**—a silicone rubber that is the intumescent of the mold giving it a spongy structure and the capability to expand into small crevices during polymerization. This foaming elastomer is similar in molecular pattern to Silastic RTV 502 except for hydrogen atoms replacing some of the methyl side groups. Four tenths mole of hydrogen gas is released as 100 gm. of this compound is polymerized.

*Silicone Fluid 200** (20 centistokes)—a silicone diluent that lessens the viscosity of

the prepolymerized liquid and softens the polymerized mold. The molecule of this fluid is similar to Silastic RTV 502 but does not polymerize.

*Stannous Octoate**—an oxidizing agent which polymerizes both the structural rubber and the intumescent by crosslinking methyl radicals.

These ingredients were mixed to the following proportions:

Silastic RTV 502.....	30 per cent by weight
Silastic Q-3-0030.....	30 per cent by weight
Silicone Fluid 200 (20 cs.).....	40 per cent by weight
Stannous octoate.....	2 ml.

Thirty grams of a radiopaque powder

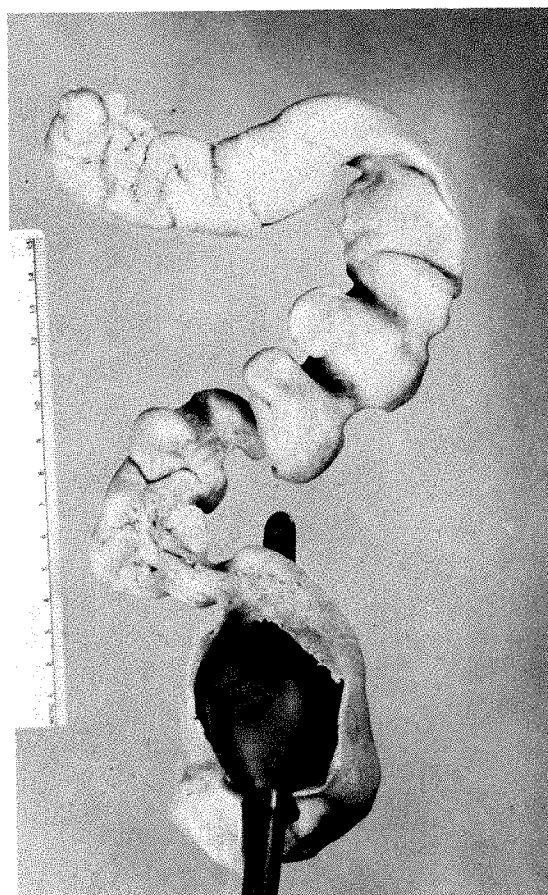


FIG. 3. Mold of a normal rectum and sigmoid. This is the first mold obtained in a human being. (Reproduced with permission from the *Surgical Forum*, 1961, 12, 310, of the American College of Surgeons.)



FIG. 4. (A) Mold of the rectum and sigmoid of a six year old boy. The arrow points to the impression of a polyp. The dark color of the imprint is due to blood localized to this impression. This study ruled out other polyps suspected in the sigmoid. (B) The supine anteroposterior roentgenogram of the pelvis in the same patient. This and a lateral roentgenogram are routinely obtained after administration of the silicone foam enema. The silicone foam mixture is more opaque during administration and becomes less opaque as gas bubbles form during polymerization. (C) Imprint of a 1 cm. polyp of the sigmoid colon (arrow with x) in a sixty-six year old woman. Next to the imprint is the resected polyp (arrow). (D) Imprint of a rectal polyp in another patient which was overlooked at the first sigmoidoscopic examination.

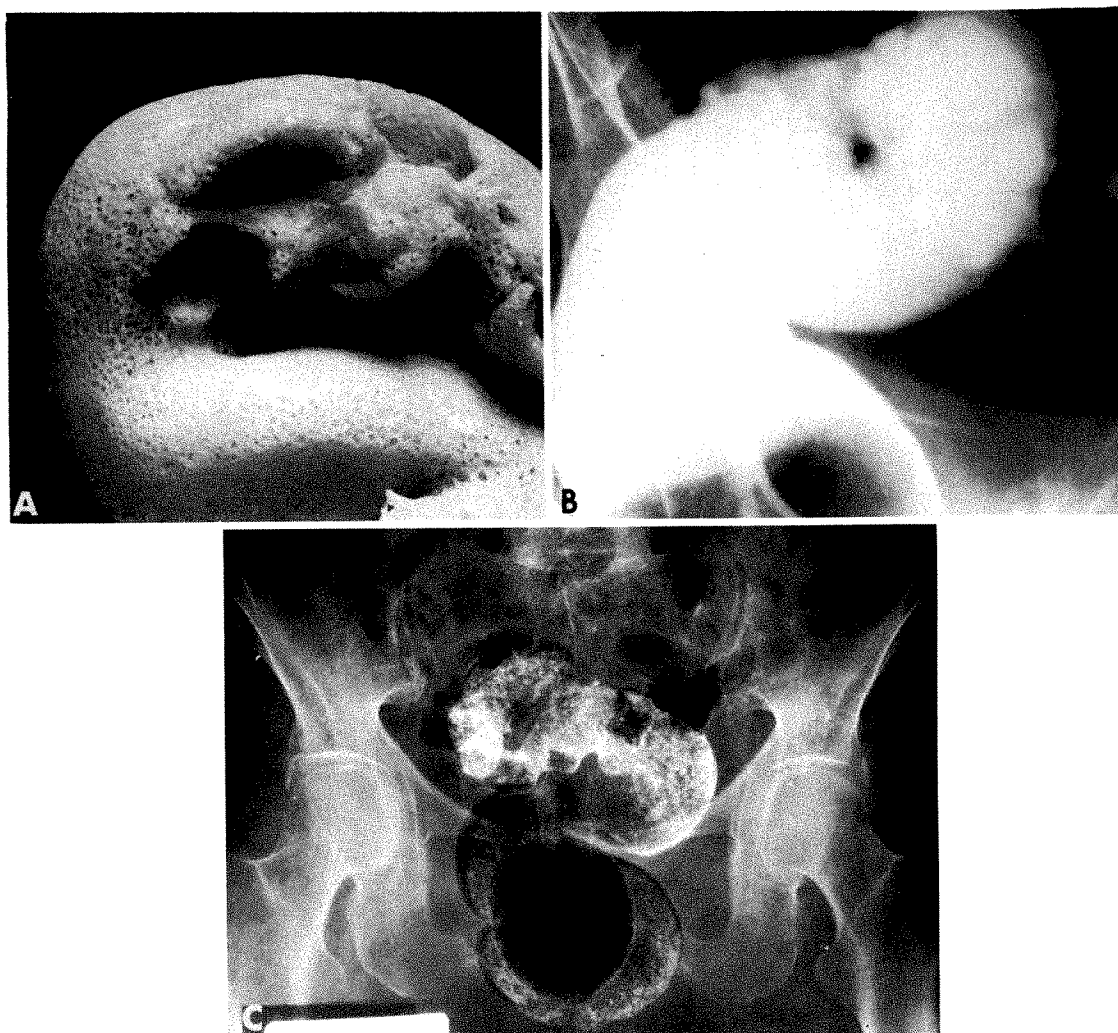


FIG. 5. Study of a polypoid carcinoma of the sigmoid in an eighty-one year old woman. (A) The silicone foam mold showing the imprint of the carcinoma to good advantage. (B) A spot film exposed during the conventional barium enema examination fails to demonstrate the lesion. Other films of the same study were not diagnostic of the lesion either. (C) The anteroposterior supine roentgenogram obtained at the completion of the silicone foam enema.

(hypaque¹ or urokon²) were dissolved in 20 ml. of tap water and added to the silicone mixture prior to the addition of stannous octoate.

ADMINISTRATION OF THE ENEMA

Those persons selected for examination were given two successive cleansing enemas (Fleet³ or Travad⁴) and allowed to expel the

contents of their distal bowel. They were then placed on a fluoroscopic table in the Sim's position and a Foley catheter (Bardex⁵) was introduced into the rectum. The balloon was inflated with approximately 100 cc. of air and slight traction made on the catheter to assure its secure position. The patients were rolled to the supine position and the fluoroscopic screen was moved to the pelvis.

¹ Winthrop Laboratories, New York, New York.

² Mallinckrodt Chemical Works, St. Louis, Missouri.

³ C. P. Fleet, Lynchburg, Virginia.

⁴ Baxter Laboratories, Morton Grove, Illinois.

⁵ Hamilton-Schmidt, St. Louis, Missouri.

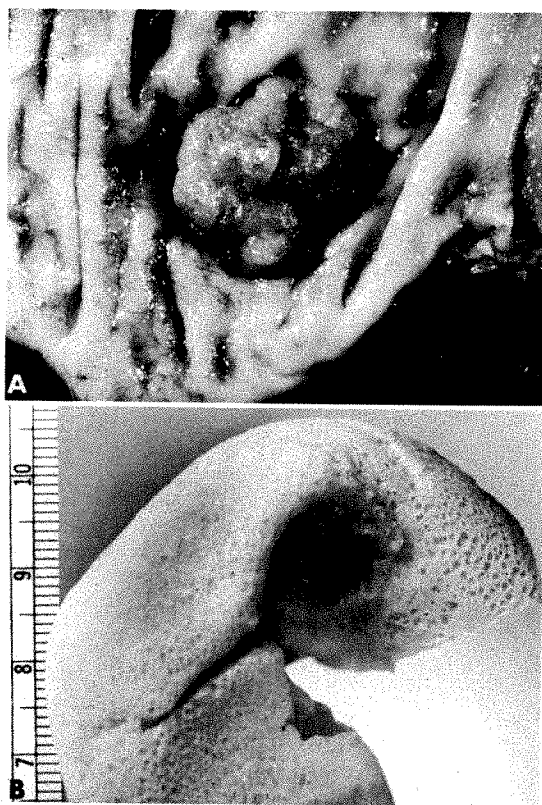


FIG. 6. Demonstration of a fungating polypoid carcinoma of the distal sigmoid in an elderly man. (A) A photograph of the polyp following resection of the bowel. (B) The imprint produced by the lesion in the silicone mold. This lesion could be seen through the sigmoidoscope but was not seen on the roentgenograms of a conventional barium enema examination.

The catalyst was added to the enema mixture and stirred thoroughly for ten seconds. The mixture was then poured into a disposable cartridge of an industrial sealant gun⁶ and introduced through the catheter with a pressure of between five and ten pounds of air per square inch. During influx, the course of the advancing radiopaque silicone mixture was observed on the fluoroscope.

Five minutes after giving the enema, an anteroposterior and lateral roentgenogram of the pelvis was made. These roentgenograms were examined and the Foley balloon was collapsed and the catheter removed.

⁶ Semco Sales and Service, Inc., Inglewood, California.

RECOVERY OF THE ENEMA

Five tenths milliliter of neostigmine was administered subcutaneously unless contraindicated and the patients were placed upon a bedpan. Most of the individuals expelled the entire mold within five minutes without pain. The molds were then examined for irregularities and adherent mucus and debris. Suspicious areas were irrigated with 50 ml. of lactated Ringer's solution which was collected and sent to the Barnes Hospital Cytologic Laboratory. The molds were then washed with detergent, dried and photographed. Afterwards, they were packaged and stored, constituting a permanent record of the individuals' lower colons.

RESULTS

This study was designed primarily to evaluate the efficacy and safety of the silicone foam enema. Consequently, many of the individuals examined had colonic lesions which were readily diagnosable by existing roentgenographic methods. Actually, in some cases the disease was readily seen through the sigmoidoscope. Other persons, however, had roentgenographic signs of disease which were at most, very inconspicuous. A few individuals were examined only because they had had rectal or sigmoid polyps removed and had been

TABLE I

<i>Material</i>	
80 patients—87 procedures	
49 males—31 females	
Age range: 6 to 88 years; 18 patients over 70.	
<i>Findings</i>	
Polyp resected.....	11
Polyp not resected.....	2
Adenocarcinoma.....	15
Lymphosarcoma.....	1
Chronic ulcerative colitis.....	4
Diverticulosis.....	3
Diverticulosis and diverticulitis.....	3
Imprints from extrinsic masses.....	2

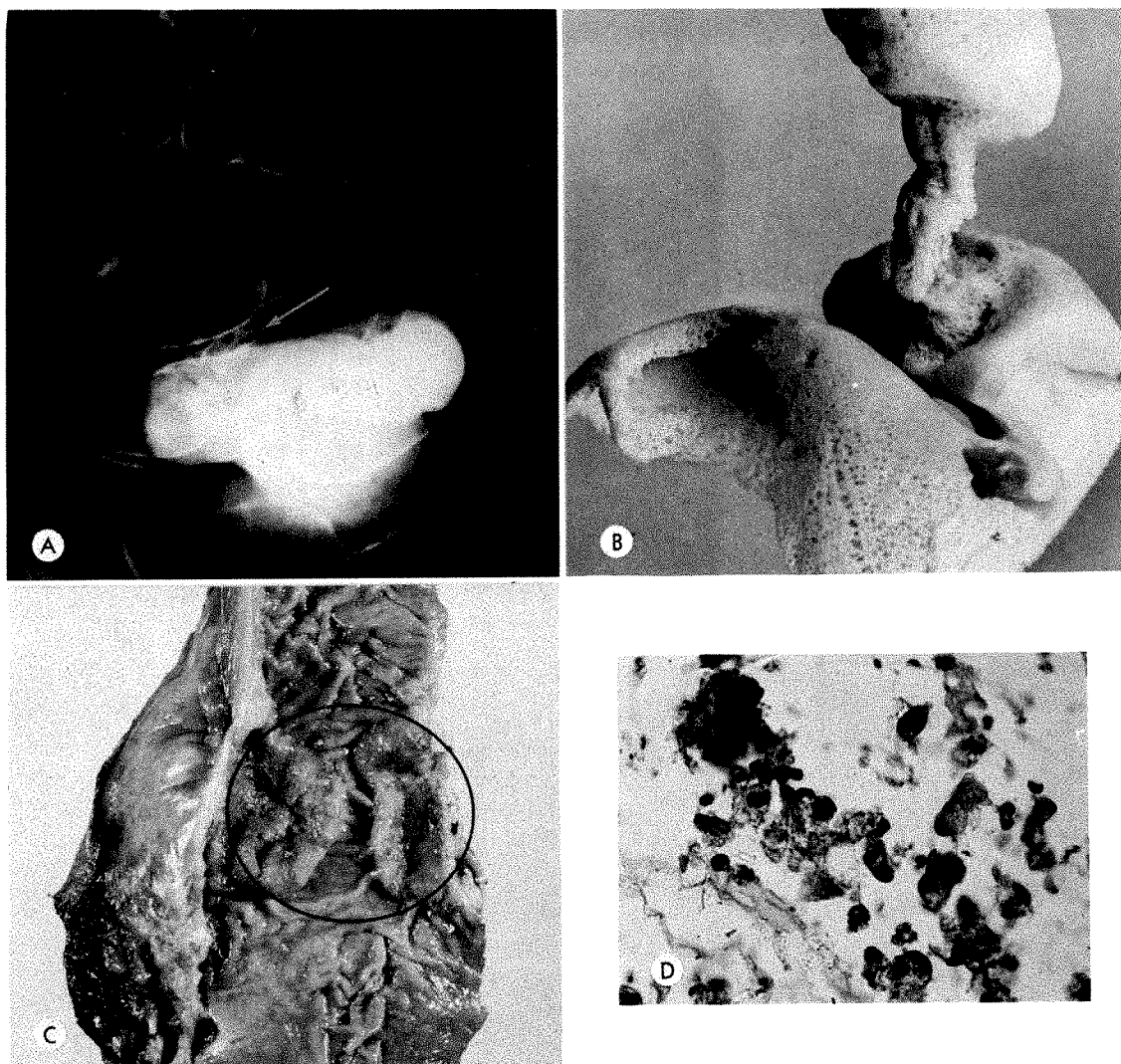


FIG. 7. Study of a carcinoma of the sigmoid in a fifty-eight year old woman. (A) A roentgenogram of a double contrast enema examination showing the lesion (arrow). (B) The silicone foam mold showing the almost completely encircling lesion. The overhanging margin of the carcinoma is brought out well. The diameter of the mold proximal to the lesion is 4 cm. The width of the channel in the middle of the lesion is 1.1 cm. (C) A photograph of the carcinoma following resection of the bowel. (D) Well differentiated carcinoma cells obtained from saline washings of the mold after spontaneous passage.

recently found not to have any colonic lesion on conventional roentgenographic examinations.

Eighty persons were examined; 31 were women. Their ages extended from six to eighty-eight years. Eighteen were seventy years old or older; of these, six were over eighty.

The molds showed deformities which were interpreted as imprints of sessile and

pedunculated polyps, ulcerated, polypoid, annular and partially obstructing carcinomas, diverticulosis, diverticulitis, ulcerative colitis, and intraluminal narrowing due to adhesions, anastomotic scars and extraluminal compression by Bloomer's shelf (Table 1). In several instances the molds were found to be free of surface defect and normal in contour when made in persons in whom the roentgenographic or sigmoido-

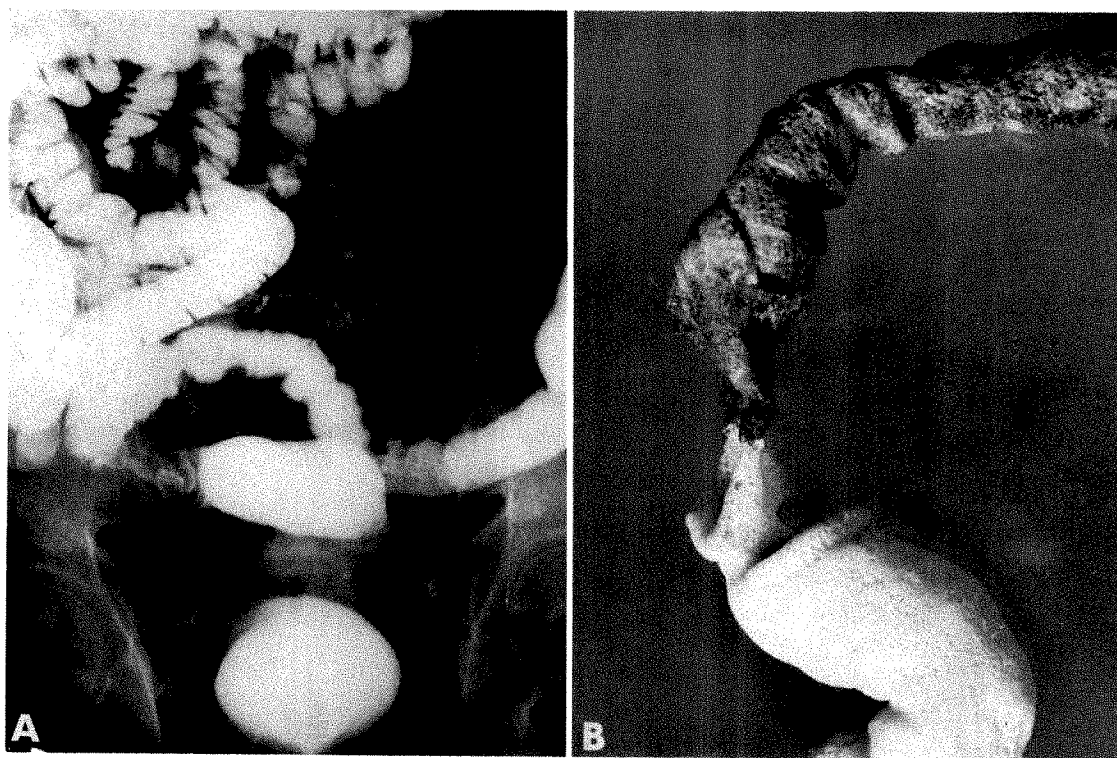


FIG. 8. (A) A prone anteroposterior pre-evacuation roentgenogram of a conventional barium enema examination. (B) A silicone foam mold showing a carcinoma of the sigmoid colon in a seventy-two year old male. The distal part of the mold was evacuated by the patient fifteen minutes following administration. The proximal part was evacuated sixteen hours later and is stained by fecal pigment. The fragments could be fitted easily.

scopic examinations were suggestive but not diagnostic of abnormality.

Cytologic examinations were made of the cells washed from the immediate area of the surface defects of thirty-five molds. The cytologic examinations of the washings

TABLE II
CYTOLOGIC STUDIES ON WASHINGS FROM
SILICONE FOAM MOLDS

Histologic Diagnosis	Cytologic Diagnosis			
	Posi- tive	Suspicious for Carcinoma	Atypi- cal Cells	Nega- tive
Adenocarcinoma	9*	3	1	0
No Carcinoma	0	0	2	21

* One case with positive washings had a noninvasive carcinoma in a sessile polyp.

from the molds of 13 persons bearing colonic carcinomas were reported by the cytologists as follows: "suspicious of carcinoma or positive" in 12 of them (Table II). The cytologists knew nothing about these patients so as not to bias their interpretations. No false positive diagnoses have been made so far. To date, there is no evidence that false negative interpretations have been made.

Forty-seven persons expelled the molds painlessly and within fifteen minutes of administration. Seventy-four persons expelled the molds painlessly and within thirty-six hours after examination. Of the 80 patients, 50 received neostigmine.

Six persons were unable to expel the mold spontaneously. Four were anxious and requested removal of the mold within twenty-four hours. Only two were unable to pass the molds within forty-eight hours. The

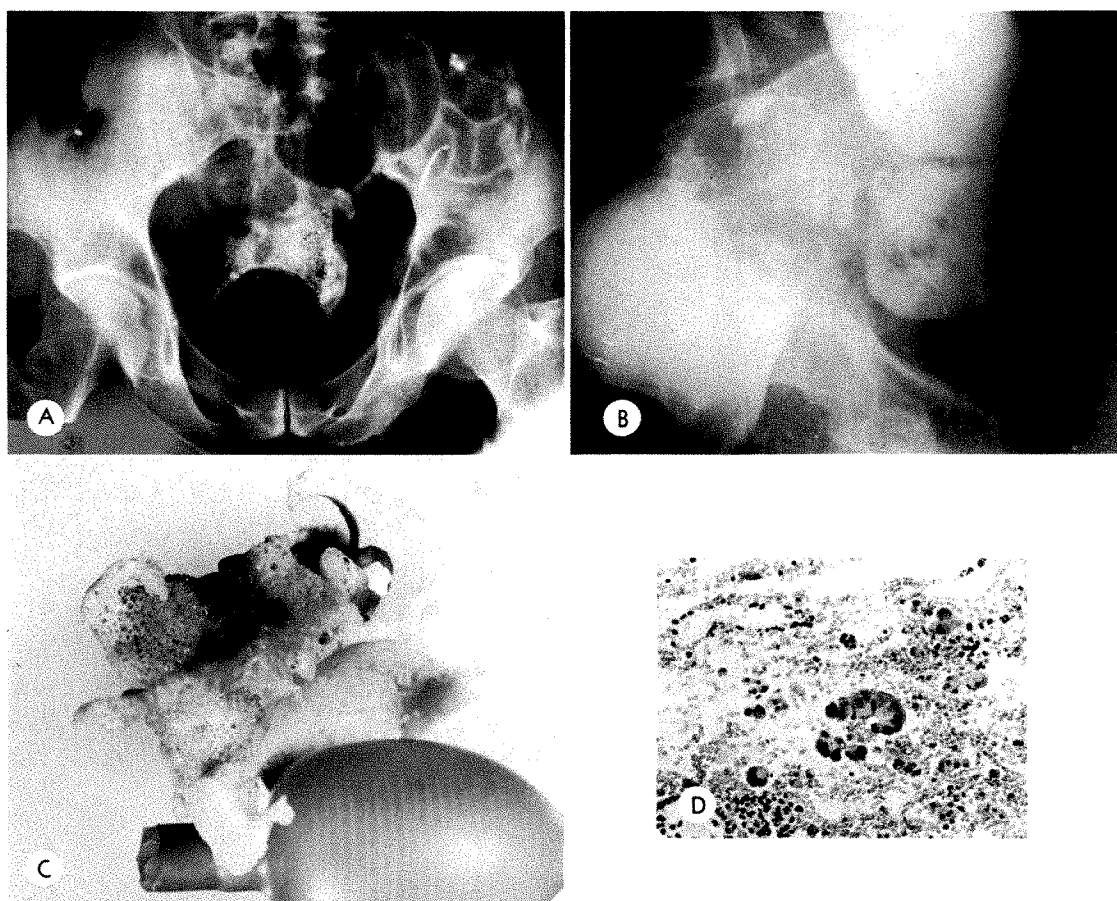


FIG. 9. Study of a large polypoid carcinoma of the rectum in a fifty-nine year old man. (A) A roentgenogram showing the mold in the rectum. (B) A lateral roentgenogram of the rectum obtained during the barium enema examination. (C) The irregular imprint of the large polypoid lesion in the silicone mold. The administration was easily controlled under fluoroscopic guide. (D) Carcinoma cells obtained by saline washings of the mold.

molds were removed from them simply and safely using only a gloved finger. Because this polymer is a soft foam, the removal of the retained mold was simpler than the removal of impacted feces. The broken fragments of the mold were then easily reassembled and an interpretation could be made. In three patients part of the mold was lost because they forgot to use the bedpan.

Although the majority of the molds had few or no artifactual defects, some had artifacts consisting of large pockets. These defects, of course, masked a portion of the mucosal surface (Fig. 11). These defects were due to gas (flatus); such gas collec-

tions exist in barium enemas but their masking effects are obviated on the post-evacuation roentgenogram by the inclusion of tannic acid in the barium sulfate suspension. When large artifacts were found near or over the region suspected of harboring a lesion, the silicone foam enema was repeated with the patient's position altered.

DISCUSSION

This method for recording intraluminal lesions of the sigmoid colon by means of a mold is simple and reliable. So far it has not been harmful in any case. Pain is not experienced during the administration nor polymerization of the mold. A sensation of

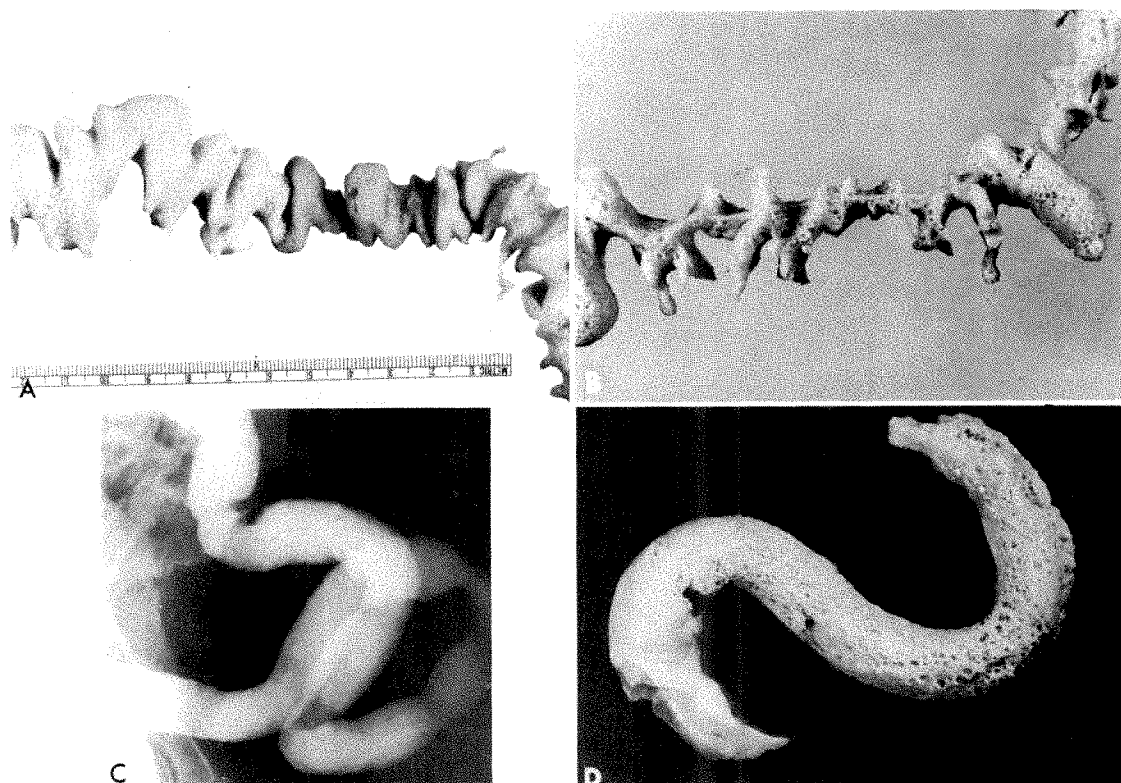


FIG. 10. (A and B) Molds of two patients with diverticulitis of the sigmoid colon. (C) A roentgenogram of the barium filled sigmoid colon and (D) a mold of the sigmoid colon in a patient suffering from an acute exacerbation of chronic ulcerative colitis.

fullness similar to that experienced with barium enemas is all that was noted. Evacuation of the mold was easy for the

74 individuals who had not become habituated to enemas or cathartics or who did not suffer with painful anal diseases.

This technique had been designed primarily for use in discovering small colonic lesions. It had theoretically seemed unwise to administer the material to persons having partially obstructing lesions of the colon because of the possibility that it might convert a partial obstruction into a complete one. However, so far in the few cases in which the foam was passed through a partially obstructing lesion, it has not lodged above nor in the narrowing. In Case 34 in which a considerable quantity of the polymer had been projected through a constricted segment of bowel having a diameter of 1.1 cm., the entire mold was passed (Fig. 7).

In this series only the rectum, sigmoid and descending colon were examined with this method. However in one case, inad-

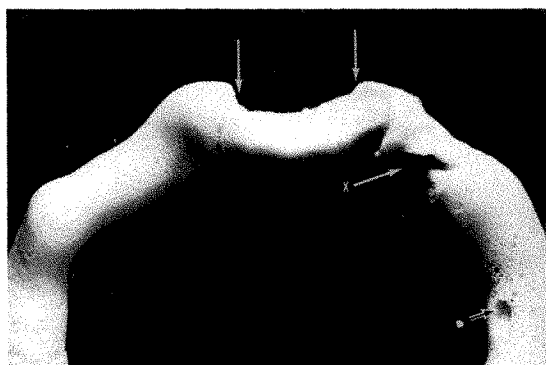


FIG. 11. Common artifacts in a silicone foam mold.

A large air-fluid level can be easily recognized by its smoothness and flatness (arrows). Fissures in the mold occur occasionally and can be identified without difficulty as the edges fit together perfectly (arrow with x). Small smooth air bubble defects can be identified because the surface is smooth and shiny.

vertently, a cast was made of the colon from the mid-transverse to the anus. Even this mold was passed without difficulty. It is possible that the method may be eventually found to be applicable for the examination of the whole colon. Should such be the case, the molds would be subject to multiple fracturing; nevertheless, the pieces could be neatly reassembled in proper order and position.

Segments which remain in the bowel longer than twelve hours are stained a deep brown. This discoloration does not interfere with interpretation (Fig. 8).

Currently, we are trying to find ways of eliminating the air-pocket artifacts.

Soon a compact, disposable unit of silicone foam will be available for general clinical use.

SUMMARY

The results of 87 experiences with the silicone foam enema as a method of examination of the rectum and the sigmoid colon are presented. The method consists of injecting rectally a radiopaque mixture containing silicone elastomers which poly-

merize at room temperature, take the shape of and imprint the mucosal detail. The elastic mold is usually evacuated spontaneously. Any part or all of the mold is washable with saline solution, and the washings constitute a good medium for a specifically localizable cytologic examination.

Based on observations on 87 examinations of 80 human beings, the method is remarkably reliable for the study of the distal colon and rectum.

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We are greatly indebted to Dr. Harlan Spjut, Associate Professor of Surgical Pathology for his interpretation of the cytologic examinations reported here and for his help and encouragement.

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PERFORMING THE BARIUM ENEMA: EQUIPMENT, PREPARATION, AND CONTRAST MEDIUM*

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THE execution of the barium enema examination is one of the most difficult tasks of the radiologist. When satisfactorily accomplished, it contributes importantly to the detection of small lesions, but when done improperly, the results may be misleading. Welin,¹⁴ using double contrast enema studies, found that in all patients examined 9.8 per cent had polyps, 81 per cent of which measured less than 1 cm. in diameter. Of the polyps resected, 18.5 per cent were malignant and 39.5 per cent were considered as precancerous on histologic examination. It is remarkable that such a crude method of investigation of an organ that normally contains a considerable amount of feces may reveal so much information.

It is evident that to obtain optimum results (1) the colon must be completely free of all particulate matter, (2) the contrast material must be in contact with the entire surface of the colon on at least one roentgenogram, and (3) the roentgen beam must be of sufficient intensity to penetrate the colon filled with contrast material. In observing the roentgenograms from this and many other institutions it was obvious that some of these conditions, particularly (1) and (2), were frequently not met.

EQUIPMENT

Previously it has been shown that, during the barium enema examination, rectal contents can pass in retrograde fashion into the enema tube to produce contamination.^{11,13} Occasionally, after completion of the procedure, feces are noted in the enema can.

The usual practice of replacing the enema tip or tubing for each patient does not prevent cross-contamination. The danger of

infection persists despite substitution of enema tips and the use of equipment cleansed with soap and water. Three solutions to the problem of contamination are possible: (1) sterilization of equipment in an autoclave after each enema. This process is expensive, time-consuming, and requires a sterilizer of sufficient size to accommodate an enema can; (2) a valve in the tube or enema tip to prevent reflux or diffusion of the bacteria when the valve is open and the flow temporarily stopped. The valve must be sterilizable or of a cost to warrant disposal. An attempt is being made to fabricate a disposable, inexpensive plastic valve that attaches to a firm disposable enema tip; and (3) an inexpensive, disposable unit, consisting of an enema reservoir, tube, and tip. This is the most practical solution.

At present, we are routinely using a disposable plastic bag, tube, and tip, made to our specifications, which has proved most satisfactory (Fig. 1).¹ The same unit is used for both cleansing and barium enema examination, and is then discarded. The bag is graduated at 1,500 and 2,000 cc. and holds 2,300 cc. of fluid. It is translucent and the level of the liquid can be seen in the fluoroscopy room so that, if necessary, fluid may be added. A zipper closure at the top of the bag prevents spillage. The bag may be agitated for mixing, or compressed when a more rapid flow is desired. The tube measures 6 feet in length and $\frac{1}{4}$ inch in internal diameter. The firm plastic tip has an expanded perforated end. We no longer hesitate to siphon the contents of the rectum and sigmoid by lowering the bag below the level of the patient's rectum, since the possibility of contaminating other pa-

¹ Walker Industries, Evanston, Illinois. Distributed by General Electric Company, X-Ray Department.

* From the Department of Radiology, University of California, School of Medicine, San Francisco, California.

tients from the enema can have been eliminated (Fig. 2). With the disposable unit, this procedure is frequently used after the completion of a double contrast enema study, at which time the patient is placed in an erect position to allow the excess barium suspension to settle in the rectum. With viscous suspensions that do not flow readily, the enema tube is cut and the excess barium suspension aspirated with a large syringe.

A simple device for introducing air into the colon during the examination consists of an insufflation bulb with an air-release valve and a plastic tube approximately 2 to 3 feet long with a No. 18 needle at its end. The needle is inserted into the lumen of the enema tube just below the point where the tube has been clamped, and gas is insufflated in the usual manner (Fig. 3). The



FIG. 1. The disposable enema unit, consisting of a plastic bag, tube, and tip, which is used for both clyso-drast cleansing and subsequent enemas with contrast material.



FIG. 2. Colonic fecal residue or excess contrast medium can be siphoned off by placing the plastic enema bag below the level of the patient's rectum. With the use of disposable enema units, the possibility of contaminating subsequent patients no longer exists.

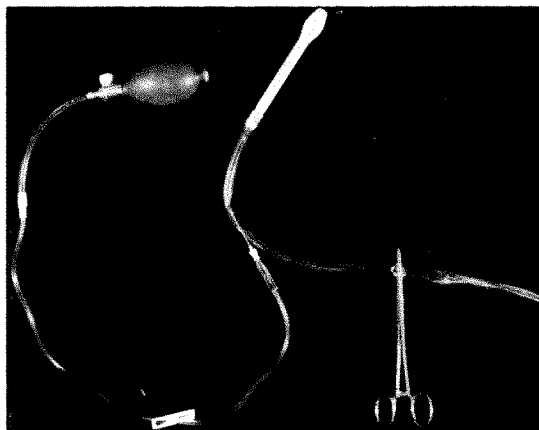


FIG. 3. A simple device for introducing air into the colon during and/or alternating with the barium enema.

narrow caliber of the needle acts as a valve, reducing the reflux of barium, and the long tube traps any barium that may have passed through the needle. The bulb is sterilized should contamination occur.

When it is necessary to use an inflatable retention catheter, the bulb of the enema tip is cut off with scissors and the remaining part of the tube is inserted into the catheter.

PREPARATION OF THE COLON

In the detection of polyps, one of the most important requisites is the preliminary cleansing of the colon. All the feces, oil droplets, and as much as possible of the mucus and gas must be removed. Formerly, with the usual preparation of a twenty-four hour clear liquid diet and 2 ounces of castor oil preceding the examination, residue in the colon often interfered with the interpretation of roentgenograms. Preliminary plain water enemas were abandoned because, in many instances, the water was not completely expelled and tended to dilute the barium introduced.

Within recent years, several cathartics have been recommended as substitutes for castor oil (dulcolax,² roenten,³ x-prep,⁴ and others). In the articles advocating their use, however, results showing good preparation occurred in only 64 per cent of examinations with x-prep,³ 73.8 per cent with roenten,¹² and 64 per cent with dulcolax.⁷ Köhler and Tähti⁸ stated that the results with castor oil and preliminary water enemas were unsatisfactory in nearly one-third of the patients examined. These studies are not comparable as it has not been possible to define the criteria for satisfactory cleansing. The methods of determining the extent of cleansing vary, some authors using plain roentgenograms and estimating the amount of gas and feces, others using barium enemas and estimating the amount of feces, gas, and oil droplets. According to Köhler and Tähti, the most

effective evacuation resulted from tablets and suppositories of metalax⁵ (the same preparation as dulcolax) but in the same report they indicated that clysodrast was used prior to any double contrast enema. We have tried dulcolax tablets and suppositories in various doses and have found them to be inferior to castor oil.

Andrén, Frieberg, and Welin's¹ success with clysodrast⁶ as a cleansing enema instigated our investigation of this substance. Clysodrast is a combination of 1.5 mg. of 4,4'-diacetoxidiphenyl-(pyridyl-2)-methane with 2.5 gm. tannic acid to increase its solubility. The effective agent in clysodrast is a nonirritant which stimulates the musculature to contract. In addition, tannic acid serves to favorably influence the deposition of barium sulfate on the mucosa and increases evacuation of the colon. Tannic acid is an astringent and tends to precipitate mucus and the protein of the superficial layers of the mucosa. It thus reduces the amount of secretion of mucus and inhibits the absorption of substances from the colon. To supplement this action, 1 mg. of atropine may be given orally. The concentration of tannic acid recommended for cleansing and barium enemas varies from 0.5 per cent to 3 per cent, whereas in the clysodrast solution we use, it is 0.25 per cent.

Welin and Brahme¹⁵ reported no adverse reactions in patients with ulcerative colitis or other inflammatory process in whom clysodrast was used. We have administered it in many such patients and noted no complications. Tannic acid in a 2 per cent solution has been used in enemas to treat ulcerative colitis, since it reduces diarrhea and controls symptoms.⁶

Errors in the literature have resulted in confusion of lavema⁷ (veripaque) with clysodrast.^{2,5,10} The two drugs are totally dissimilar. The recommended dosage of the active agent in lavema (3,3-bis (4-hydroxyphenyl) oxindole) is from 6 to 13 times as

² Dulcolax (Geigy)

³ Roenten (Brayton)

⁴ X-Prep (Gray)

⁵ Metalax (Star, Tampere, Finland)

⁶ Clysodrast (A. B. Ferrosan, Malmö, Sweden)

⁷ Lavema (Winthrop)

great as that of clyso-drast. In our trials of lavema in the recommended dosage as a preparatory enema, many adverse side reactions and considerable spasm of the colon occurred. Barnhard and Crow² claimed that the use of distilled rather than tap water to dissolve lavema prevented the adverse reactions. They did not advise lavema, however, in routine preparatory procedures for barium enema examination because of the resultant poor mucosal detail on roentgenograms.

EVALUATION OF THE RESULTS

Clyso-drast enemas were given immediately preceding the barium enema examination. If a large quantity of feces was expelled into the toilet, indicating poor preliminary preparation, the clyso-drast enema was repeated. The initial preparation of the patient consisted of a twenty-four hour clear liquid diet and a cathartic of 2 ounces of castor oil or 4 ounces of neoloid, or dulcolax in the amount of 15 or 25 mg.

Table I compares the results using different cathartics followed by clyso-drast enemas of various concentrations in 500 consecutive unselected patients. The patients represent both sexes, ranging in age from eight to eighty-four years. The results, regardless of the preliminary preparation, were usually satisfactory. Even in 41 patients who had had no preliminary cathartic or special diet, the cleansing was judged

TABLE I
COLONIC PREPARATION USING CLYSODRAST
ENEMAS IN VARIOUS CONCENTRATIONS

Preparation a Day Prior to the Clyso-drast Enema	No. of Clyso- drast Enemas	Results	
		Satis- factory	Not Satis- factory
Castor oil, 2 oz.	189	176	13 (7%)
Neoloid, 4 oz.	70	66	4 (6%)
Dulcolax, 15 mg.	41	33	8 (20%)
Dulcolax, 25 mg.	159	139	20 (13%)
No preparation	41	34	7 (17%)
	500	448	52 (10%)

TABLE II

COLONIC PREPARATION USING 900 CC. OF A SOLUTION
CONTAINING 2 PACKETS (5 gm.) CLYSODRAST
IN 1,500 CC. WATER

Preparation a Day Prior to the Clyso-drast Enema	No. of Clyso- drast Enemas	Results	
		Satis- factory	Not Satis- factory
Castor oil, 2 oz.	82	75	7 (9%)
Neoloid, 4 oz.	32	31	1 (3%)
Dulcolax, 25 mg.	71	65	6 (8%)
	185	171	14 (8%)

adequate in 34. These results appear to be better than those obtained with 15 mg. of dulcolax followed by the clyso-drast enema, but this is probably erroneous due to the small number of patients examined without preparation. The over-all results would appear better than those in most published reports on the use of the cathartics alone. These impressions of results of preparation are subjective, however, and should not be compared to the impressions of others.

In Table II, 185 examinations are tabulated. This group of patients received a concentration and quantity of clyso-drast solution considered to be a compromise between the dosage for adequate preparation and that for avoidance of spasm of the colon. Approximately 8 per cent of the 185 examinations were considered unsatisfactory for one of the various reasons mentioned previously. This figure is a considerable improvement over our earlier experience without the use of preparatory clyso-drast enemas.

The results following dulcolax appear to be as good as those following castor oil or neoloid⁸ (which contains castor oil as the effective agent) provided that the cathartic is followed by an enema containing clyso-drast in adequate concentration.

In the unsatisfactory examinations (Tables I and II), in some patients the colon was not completely clean, in others gas was a problem, and, in a third group, spasm in-

⁸ Neoloid (Lederle)

TABLE III
REACTIONS TO CLYSODRAST ENEMA

Concentration of Clysodrast	No. of Patients	Reactions
5 gm. in 1,500 cc.	106	33 (31%)
2.5 gm. in 1,500 cc.	12	1 (8%)
2.5 gm. in 1,000 cc.	135	12 (9%)
2.5 gm. in 900 cc.	42	2 (5%)
2.5 gm. in 750 cc.	20	1 (5%)
	315	49 (15%)

terfered with the procedure. Different radiologists, some more exacting than others, reviewed the roentgenograms. The results given in the tables, however, are the evaluations that the average radiologist would make from these roentgenograms.

To date we have given clysodrast enemas to more than 5,000 patients. The only side effect was cramping, which in a few patients was associated with fainting. The side reactions tabulated in 315 examinations (Table III) were, in general, proportional to both the amount of fluid introduced and the concentration of clysodrast in solution. When used as recommended,^{1,14} 5 gm. in 1,500 cc. of water, the incidence of cramping was 31 per cent and a considerable amount of spasm was noted during the enema. One packet of clysodrast (2.5 gm.) dissolved in 900 cc. of water reduces the incidence of pain to about 5 per cent. However, pain is not necessarily a result of the clysodrast, since, occasionally, patients experience severe cramps with saline or plain water enemas, particularly if preceded by a cathartic, or if disease of the colon is present. In no case was discontinuance of the examination necessary.

From our experience, we conclude that the preliminary enema with clysodrast in a concentration of about 2.5 gm. in 1,000 cc. of water is a most useful procedure. That a clear liquid diet and purgative alone is not completely successful as a preliminary preparation is easily proved by observing the amount of fecal material expelled after the clysodrast enema in some cases. If fol-

lowed by a clysodrast enema, the preliminary preparation can consist of dulcolax.

With the amount of clysodrast recommended, spasm of the cecum following filling and distention may be noted. Spot roentgenograms, therefore, should be obtained of the cecum as it fills initially.

The use of clysodrast increases the tonus of the colon and ileocecal valve so that the caliber is diminished and the tendency to reflux into the ileum is reduced. Since a filled ileum frequently interferes with subsequent examination of the sigmoid colon, the increased resistance to filling aids in the examination of the colon. Filling of the ileum, if desired, is sometimes accomplished by elevating the can to increase the pressure, or by waiting thirty minutes or more after the cleansing enema to introduce the contrast medium. Waiting also reduces the frequency of spasm of the cecum.

CONTRAST MEDIUM FOR BARIUM ENEMA EXAMINATION

Barium sulfate has been prepared with many modifications to prevent sedimentation. Many radiologists, however, continue to use mixtures of U.S.P. barium sulfate and water, without adding a suspending agent. Most reports regarding stabilized suspensions discuss their use in examinations of the stomach and small intestine, and in double contrast studies of the colon. It would appear that these stabilized suspensions are of particular importance in the barium enema study. The ordinary barium sulfate separates rapidly from the suspension in water, even when stirred intermittently, and it is not agitated by peristalsis of the colon, as is the case in the stomach or small intestine.

Studies were conducted to show the sedimentation rate of various preparations, both in paper cups and *in vivo*. Suspensions of barium sulfate, barotrast,⁹ baraloid,¹⁰ baridol,¹¹ micropaque,¹² barium sulfate with

⁹ Barotrast (Barnes-Hind)

¹⁰ Baraloid (Bell-Craig)

¹¹ Baridol (Pacific Chemicals)

¹² Micropaque (Picker)



FIG. 4. Roentgenograms of paper cups containing four different contrast media taken (A) fifteen minutes and (B) three hours after mixing with an electric blender. Barotrast (left) maintained almost complete and uniform suspension. A surface layer of foam is present on micropaque (left middle) of 1.5 cm., and on baraloid (right middle) of 3 mm. Barium sulfate and water (right) show marked sedimentation.

rugar, and barium sulfate containing carboxymethylcellulose were each used in the experiments. Each substance was mixed with water in such proportion that it contained approximately an equal amount of barium sulfate. An areometer¹³ with the specific gravity reading set to "1," gave the density preferred for the barium enema suspension. The manufacturers' recommendations for preparing the substances vary, but we found that mixing any of the preparations with a high speed electric blender for thirty seconds was sufficient to produce the amount of stabilization characteristic for that substance. Tap water at approximately room temperature was used since barium enema preparations at various temperatures had given the same results in our experience.

Experimental Results (Fig. 4, A and B). Barium sulfate and water precipitated within a few minutes, forming a layer of barium sulfate at the bottom of the cup which increased over a period of time.

¹³ Ba-test Areometer (Philips Röntgen, Stockholm, Sweden)

When barotrast was used, it formed a very thin radiopaque layer along the bottom surface of the cup with little further change over an extended period. Approximately the same results were obtained with micropaque powder, although it showed foaming on the surface. (The liquid form of micropaque, not commercially available in this country, does not foam.) Baraloid remained in suspension longer than the other preparations, with very little precipitation visible even after twenty-four hours. A thin surface layer of foam was present initially on the baraloid, persisting throughout the experiment. There was evidence of a meniscus extending up the wall of the cup. This capillary rise and undesirable foaming apparently resulted from diminished surface tension. The addition of 1 part of rugar to 10 parts of barium sulfate and water, with an areometer reading of "1," will diminish sedimentation, but this preparation, too, foams on the surface (see Addendum).

In Vivo Results. In patients receiving



FIG. 5. Layering of barium, water, and gas is seen in the lateral decubitus roentgenogram after a conventional enema with barium sulfate and water.

routine barium enemas, the same phenomenon of sedimentation was demonstrated. Ordinary roentgenograms were supplemented by views obtained with a horizontal beam, with the patient in the erect or lateral decubitus position. With ordinary barium sulfate and water, roentgenograms showed layering, frequently with the gas lying superiorly, the clear liquid intermediately, and the dense barium sulfate lowermost in the colon (Fig. 5).

In patients examined with stabilized suspensions, no layering was seen. A small dense line about 1 mm. thick, immediately



FIG. 6. With the use of a stabilized barium suspension, only minimal sedimentation is observed. The radiolucent layer of water seen here is not present in the lateral decubitus position.

adjacent to the mucosa in the lowest part of the colon, was present when barotrast was used (Fig. 6).

On roentgenograms obtained in the conventional manner with a vertical beam, using a plain barium sulfate suspension, a clear zone is frequently seen adjacent to both walls (Fig. 7). It represents the clear liquid and gas above the precipitated barium sulfate, interpreted by some radiologists as mucus. From these roentgenograms, it is apparent that it is supernatant liquid and gas which occupies the upper half, or less, of the lumen of the colon. A small polyp projecting into it, therefore, would not be detected. To demonstrate this, a plastic ball of tissue density was suspended in the upper third of cups containing ordinary barium sulfate and water and barotrast and water, of equal density. In exposing the roentgenograms with a ver-

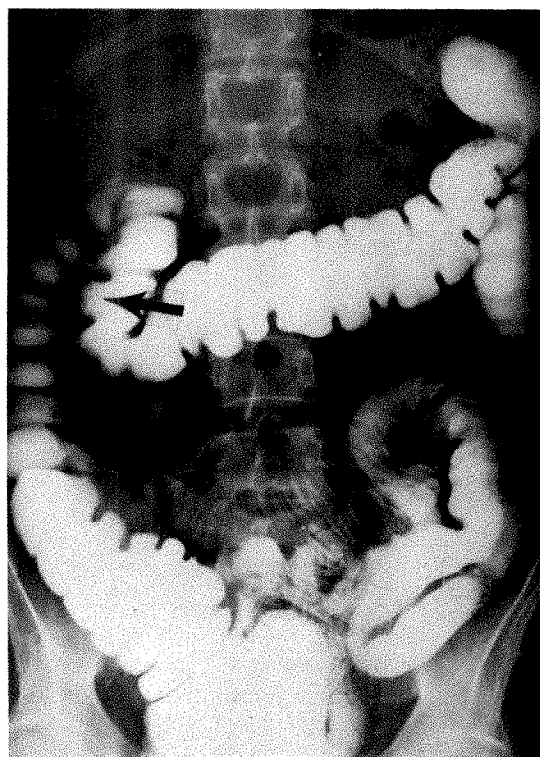


FIG. 7. Anteroposterior roentgenogram after conventional enema with barium sulfate and water. The radiolucent zone (arrows) between the barium column and the colonic wall represents the clear liquid and gas above the precipitated barium sulfate.

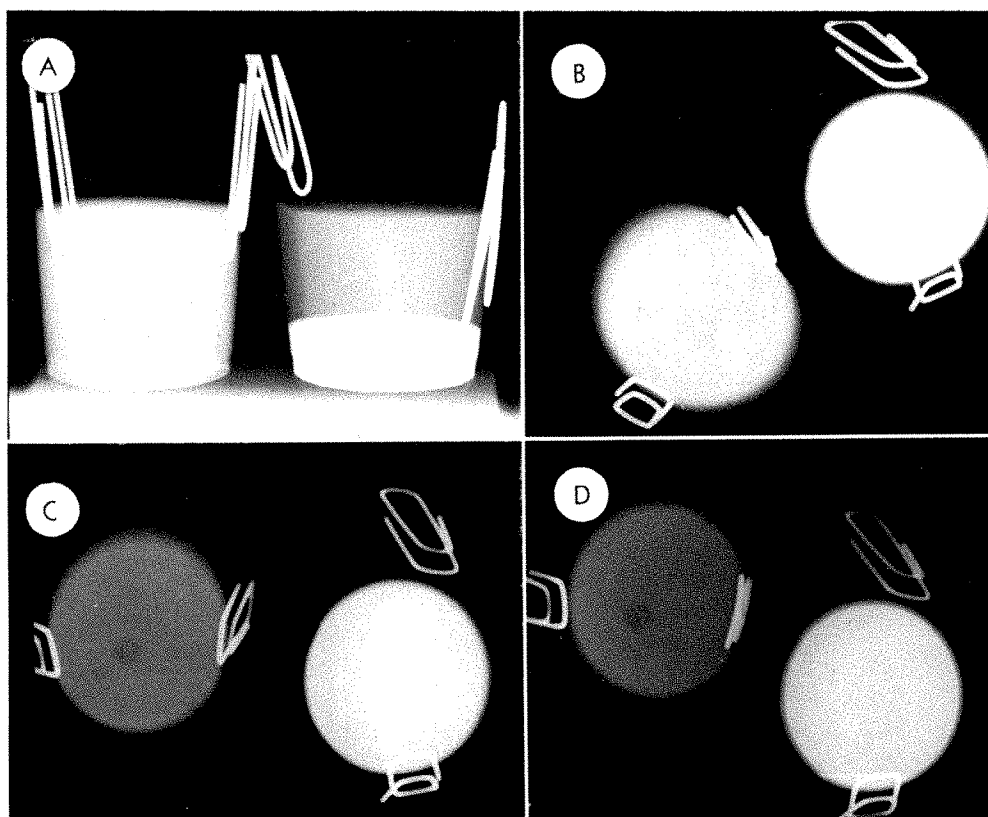


FIG. 8. (A) The advantage of a stabilized suspension is apparent when a small plastic ball (polyp), of water density, is suspended in a paper cup filled with barotrast (left) and a cup containing barium sulfate and water (right). (B, C and D) When exposed with a vertical beam, the ball can be seen only in the left paper cup (barotrast). Sedimentation in the right cup prevents noticeable contrast between the plastic ball and the surrounding dilute supernatant fluid. It is of interest that the object is seen best when using higher kilovoltage (D).

tical roentgen-ray beam, the plastic ball (polyp) was visible in the barotrast suspension but not in the barium sulfate and water preparation (Fig. 8, A-D). Also of interest was the increasing visibility of the plastic ball with increased penetration of the barium column which, in this instance, was achieved by raising the kilovoltage.

Comment. Barium sulfate and water preparations, therefore, are not adequate for detecting small polyps in the upper part of the colon unless roentgenograms, both in the supine and prone positions, are obtained. Even then the colon may rotate so that the upper part of the colon does not become dependent when the prone position is changed to the supine. The necessity of obtaining roentgenograms with sufficient penetration is clearly demonstrated. The

structures behind the colon should be visible and, if two loops overlap, the roentgen-ray beam should penetrate both. High kilovoltage is best for these roentgenograms, although, when obtained in this manner, they are necessarily dark and some of the details of adjacent structures are obscured. It is our practice to obtain lighter exposures following evacuation.

Disadvantages of Stabilized Suspensions. The disadvantages with the use of stabilized suspensions are: (1) The preparation is more expensive. Barotrast, which is used in our department, costs approximately 10 to 15 cents more per patient, which represents about 0.5 per cent of the total cost to the patient. (2) All of the stable suspensions tested were more viscous than ordinary barium sulfate and water. For this reason,

tubing of at least 5/16 inch in caliber is desirable so that the introduction of the medium into the colon is not prolonged. The use of relatively dilute suspensions also facilitates the flow. (3) The stable suspensions, in general, adhere to the apparatus. The difficulty of cleaning the apparatus is overcome with the use of disposable enema units. (4) Early in our experience with barotrast, we were disappointed with the poor evacuation and with the poor detail of the mucosa that was obtained on roentgenograms after the patient had expelled the enema.

Some of these disadvantages were partially obviated by using more diluted suspensions. Tannic acid in a low concentration that had previously been satisfactory with ordinary barium sulfate was tried but proved to be ineffective. With the concentration raised to from 0.8 to 1.0 per cent, however, good evacuation and mucosal detail were obtained. The action of tannic acid in coating intestinal mucosa remains poorly understood and many radiologists use it in varying amounts, guided by their experience in obtaining good evacuation. The use of tannic acid prevents the presence of large amounts of barium that interfere with subsequent examinations. Although intestinal cramps result from the addition to the enema of tannic acid in higher doses, we found no serious complications reported in the literature. "Episodes of syncope, marked tetanic type contractions of the colon, and occasionally true temporary shock" have been seen.⁹

ROENTGEN TECHNIQUE

With barotrast, coating of the mucosa on the postevacuation roentgenogram appears thinner than with barium sulfate and water because of the diminished precipitation. The mucosal pattern, however, is usually fine and feathery, and adequate for diagnostic purposes. For diagnosis, we consider as most important those roentgenograms made with the colon filled. This opinion is contrary to that of Christie *et al.*⁴ who detected 90 per cent of the polyps on post-

evacuation roentgenograms and only 10 per cent with the colons filled. Their roentgenograms with the colons filled were probably not satisfactory according to present day standards. Our experience of detecting polyps 3 mm. in diameter is also contrary to their statement that lesions smaller than 1 cm. were not apt to be seen. In the polyps detected by Welin,¹⁴ 81 per cent were less than 1 cm. in diameter.

The incidence of disease in the rectum and sigmoid colon is greater than in other parts of the colon. Of particular importance to radiologists is the large number of polyps and neoplasms in those regions. Special attention, therefore, should be directed to the examination of the rectum and sigmoid. Spot roentgenograms, preferably with high kilovoltage for good penetration, and compression when possible, should be obtained.

A single, large spot roentgenogram of the rectum and sigmoid is not as satisfactory as multiple small ones with the compression cone in place. Small roentgenograms can be obtained using different degrees of rotation to avoid overlapping folds. The cone, in addition to compressing the colon, limits the amount of tissue that the roentgen-ray beam traverses and, acting as a diaphragm, serves to diminish scattering. In addition, the large roentgenogram may be of adequate density for studying the sigmoid, but may be underexposed on oblique projections of the rectum or rectosigmoid.

Even with extensive precautions, some gas invariably remains in the colon. It is frequently trapped in the sigmoid area, sometimes simulating polyps. Changing the position of the patient to an erect or semi-erect position may help in such cases. This movement causes the gas bubbles to rise into the curve of the rectosigmoid where they coalesce, or into the descending colon or splenic flexure, leaving the sigmoid relatively gas-free. Gas is frequently introduced into the colon during the cleansing or barium enema. This may be avoided by allowing the fluid to pass through the tube and enema tip into a container before the tip is inserted into the rectum. If the tip is

held vertically, however, the fluid tends to run out of the tip and is replaced by gas. In this manner, as much as 4 to 5 cc. of gas may be introduced. By holding the enema tip in a horizontal position during the flushing, and by maintaining it as nearly as possible in this position when inserted into the rectum, the introduction of gas may be avoided.

CONCLUSIONS

Double contrast examination as the initial and routine roentgen investigation of the colon is not practical for most radiologists. Improvement in technique for the conventional barium enema study is, therefore, needed to diagnose small lesions in the lower intestinal tract. Complete preliminary cleansing of the colon is essential.

The barium enema examination in this institution is accomplished with the following preparation, equipment, and contrast medium.

1. Clear fluid diet for at least twenty-four hours prior to examination.
2. Two ounces of castor oil at 6 P.M., and tap water enema on the evening preceding examination.
3. Cleansing enema in the Radiology Department just prior to examination, using a concentration of 2.5 gm. of clysodrast to 1,000 cc. of tap water and given by the nurse or nurse's aide.
4. Barium enema examination with freshly prepared barotrast and added tannic acid; density determined by areometer reading of "1."
5. Same plastic disposable enema equipment used for both clysodrast cleansing and subsequent barium enema in each patient.

SUMMARY

Cross contamination, produced by conventional enema equipment, is eliminated by the use of a disposable unit consisting of a plastic tip, tube, and bag.

Excess barium contrast medium may be siphoned from the colon by holding the disposable enema bag at a point below the

level of the rectum without fear of contaminating subsequent patients. If the barium suspension is viscous, the enema tube can be cut and barium aspirated with a large syringe.

None of the cathartics available at the present time are completely satisfactory in eliminating all particulate matter and gas from the colon. An enema containing clysodrast, to supplement the usual preparation by cathartics and clear liquid diet, improves cleansing of the colon. The advantages and disadvantages of the preparation are discussed.

The enema with plain barium sulfate and water is not satisfactory for the contrast study because of rapid sedimentation. Addition of stabilizing agents will prevent sedimentation. Several more or less stabilized suspensions are commercially available and some of these preparations are evaluated.

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ADDENDUM

Since this manuscript was submitted, Umbaryt C (Röhm & Haas, Darmstadt) and the liquid form of Micropaque (Damaney & Company Ltd., Ware, England) were also tested. Both showed the same characteristics as described for Barotrast.

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THE DIAGNOSIS AND TREATMENT OF DILATATION OF THE COLON IN SEVERE ULCERATIVE COLITIS*

A DIAGNOSTIC ROENTGEN SIGN

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THE prompt recognition of acute colonic dilatation during the course of ulcerative colitis is important because of its prognostic significance. Our own experience leads us to believe that it is possible to diagnose this complication of the disease in its preperforative stage by the characteristic roentgen appearance confirming the clinical findings. This phase in ulcerative colitis is manifested clinically by toxicity, abdominal distention and tenderness, and may be confirmed roentgenographically.

The first detailed description of this entity was given by Madison and Barger⁶ in 1951. Following this paper, the entity was recognized more frequently and was subsequently described by Lumb *et al.*,⁵ Roth *et al.*,¹² and others (Table 1).

The phase of colonic dilatation has usually been described as ulcerative colitis, complicated by toxicity and abdominal tenderness. This entity of acute dilatation, however, is a separate and distinct complication requiring a different therapeutic approach from that employed during the other phases of ulcerative colitis. Roentgenographic examination of the abdomen without the use of contrast media can, we believe, provide correct diagnosis of this serious complication. Failure to recognize this entity results in a high mortality rate.

The increasing awareness of this complication of ulcerative colitis has been the result of our experience with 7 such patients seen at Montefiore Hospital. Recognition of the earlier stages of the colonic dilatation has been possible because of the roentgen findings which will be described.

REPORT OF CASES

CASE I. Patient J.E., Chart #104577 (6/8/59). This was the third Montefiore Hospital admission of a fifty-eight year old white male with an eight year history of left lower quadrant pain and a weight loss of 40 to 50 pounds in the preceding four months. A diagnosis of ulcerative colitis was established by rectal biopsy and roentgenograms of the colon (Fig. 1, A and B).

Steroids had been given for the previous three months. Physical examination showed a moon-faced lethargic and chronically ill male. A thickened, enlarged, tender loop of bowel was palpated in the left lower quadrant. Bowel sounds were diminished. The temperature was 102° F., hematocrit 34 per cent, white blood cell count 7,700, with a shift to the left and toxic granulations of the polymorphonuclear cells. Serum potassium was 5.2 mEq/L, and the other electrolytes were also normal.

Despite six weeks of intensive medical therapy, including antibiotics, blood, ACTH, and prednisone, the left lower quadrant tenderness did not subside. A subtotal colectomy and ileostomy were performed for a suspected and proved localized perforation. The resected colon demonstrated marked inflammation and pseudopolypoid formation. Granulation tissue encased the distal portion of the resected colon. Despite blood transfusions, antibiotics, steroids, fluid and electrolyte replacement, the patient died on the eleventh postoperative day of *E. coli* peritonitis. At postmortem examination, pulmonary emboli, thrombosis of the left popliteal vein, and a hemorrhagic infarct of the right lower lobe of the lung were also found.

Comment. During the six weeks of intensive treatment with blood transfusions, steroids and antibiotics, the patient presented all the clinical characteristics of

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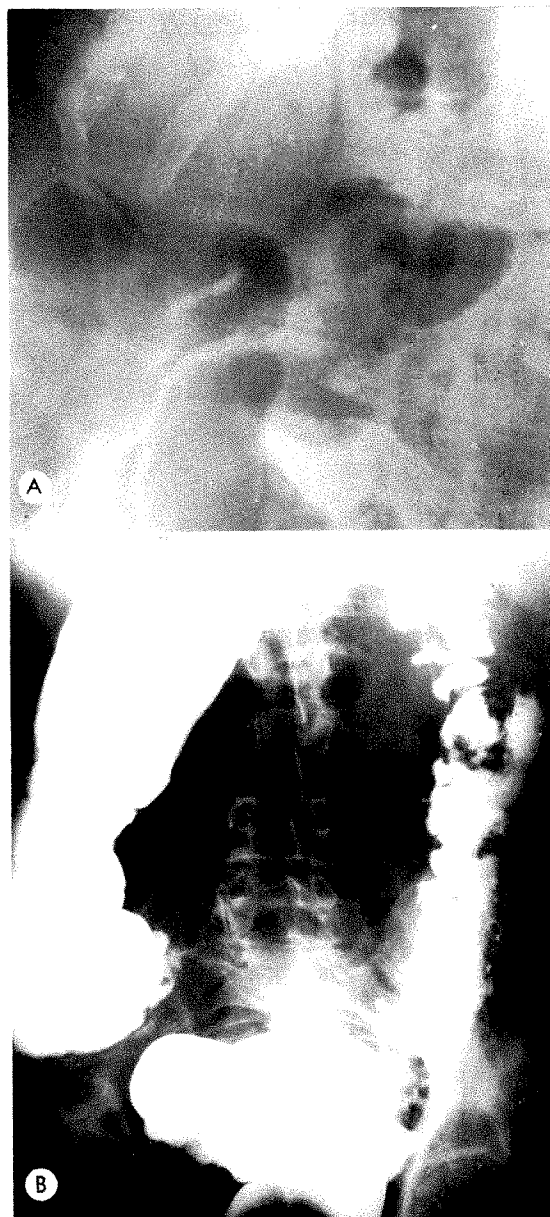


FIG. 1. Case I. (A) Roentgenogram of the abdomen—close-up view of the right upper abdomen. Moderate gaseous distention of the hepatic flexure of the colon with radiolucent stripe above the flexure. (B) Barium enema study demonstrating multiple deep ulcerations of the descending colon.

dilatation of the colon.

This was demonstrated by roentgenologic examinations of the abdomen, continual signs of toxicity, and a left shift in the patient's white blood cell series.

The unsuccessful medical management

followed by surgery, which probably extended the peritonitis into a generalized infection, resulted in the patient's death.

CASE II. Patient M.S., Chart #100351 (10/23/59). This was the third Montefiore Hospital admission of a thirty-eight year old white female with bloody diarrhea, abdominal distention and anorexia. The diagnosis of ulcerative colitis was established by rectal biopsy and barium enema examination seventeen months before this admission. Steroids had been given intermittently. Examination revealed marked tenderness and guarding of the left lower quadrant with abdominal distention and diminished bowel sounds. Her toxicity was manifested by fever, leukocytosis of 10,500 with a shift to the left and toxic granulations of the white blood cells. Potassium was 5.1 mEq/L. There was a temporary improvement with ACTH and methylprednisolone. Although the distention seemed to subside initially, it recurred again with marked tenderness in the left lower quadrant (Fig. 2, A, B and C).

Subtotal colectomy and ileostomy were performed five weeks after admission. At operation, a perforative peritonitis was encountered. A hemorrhagic colon with acute ulcerations was found. The postoperative course was stormy, with development of a subphrenic abscess, oliguria, peritonitis and finally a lung abscess. Despite adequate amounts of steroids, electrolytes, blood transfusions, fluids, and surgical drainage, the patient died six weeks after surgery. On postmortem examination, the patient was found to have a subdiaphragmatic abscess, a diffuse organizing peritonitis and focal abscesses in the lung. *E. coli*, *Aerobacter aerogenes* and *Pseudomonas aeruginosa* were cultured from the peritoneal cavity.

Comment. The same course of events occurred in this as with the preceding patient. Delayed recognition of the perforative peritonitis prompted prolonged medical therapy. Subsequent surgery then turned a localized peritonitis into a generalized process. Death of the patient resulted from the peritonitis and multiple complications.

CASE III. Patient H.M., Chart #57391 (10/26/59). This was the fourth Montefiore Hospital admission of a forty-six year old male with a two week history of bloody diarrhea, and a twenty-five year history of abdominal

TABLE I
EXPERIENCE WITH ACUTE DILATATION OF THE COLON IN ULCERATIVE COLITIS

Authors	No. of Cases	Sex	Age Range	Duration of Disease	Therapy			No. of Survivors	No. of Deaths
					Medical	Surgical	Steroids		
Madison and Borgen ⁶ 1951	1	M	49	12 yr.	1 —	Medical	0 —	1	0
						Surgical			
Lumb <i>et al.</i> ⁵ 1956	7	5M 2F	20— 70 yr.	1 mo.— 16 yr.	2 (1 alive)	—	0 —	3	4
						5 (2 alive)	1 (1 alive)		
Roth <i>et al.</i> ¹² 1959	12	8M 4F	20— 66 yr.	1 mo.— 14 yr.	6 (5 alive)	—	2 (2 alive)	9	3
						6 (4 alive)	3 (2 alive)		
Marshak <i>et al.</i> ⁷ 1960	16	4M 12F	17— 62 yr.	1½ mo.— 15 yr.	5 (3 alive)	—	3 (2 alive)	13	3
						11 (10 alive)	11 (10 alive)		
Peskin and Davis ⁹ 1960	9	3M 6F	18— 40 yr.	1½ mo.— 7 yr.	0 —	—	—	6	3
						9 (6 alive)	6 (3 alive)		
Montefiore Hospital 1960	7	5M 2F	13— 61 yr.	6 mo.— 25 yr.	1 (1 alive)	—	1 (1 alive)	3*	4
						6 (2 alive)*	6 (2 alive)		

* One survivor died of peritonitis 6 months after recovery from the acute illness following colectomy.

distress and intermittent bloody diarrhea. Continuous therapy of small amounts of steroids was given for the seven months before this admission. A barium enema study demonstrated findings of chronic ulcerative colitis (Fig. 3, A, B and C). Physical examination revealed a seriously ill patient with tachycardia, abdominal distention, diffuse abdominal tenderness and virtually absent bowel sounds. Hematocrit was 29 per cent, white blood cell count 4,600, with a marked shift to the left and toxic granulations of the polymorphonuclears.

A subtotal colectomy and ileostomy were per-

formed three days later because of the persistence of the abdominal and laboratory findings. A dilated colon with perforation of the descending colon was found. The mucosa of the colon was replaced by small pseudopolyps and intervening areas of ulceration, with complete loss of normal mucosal pattern. The submucosa was heavily infiltrated by plasma cells, histiocytes and lymphocytes, and in some areas, the serosa was vascularized and infiltrated by the same cells. In spite of massive supportive therapy after operation, the patient died of peritonitis on the ninth postoperative day. At

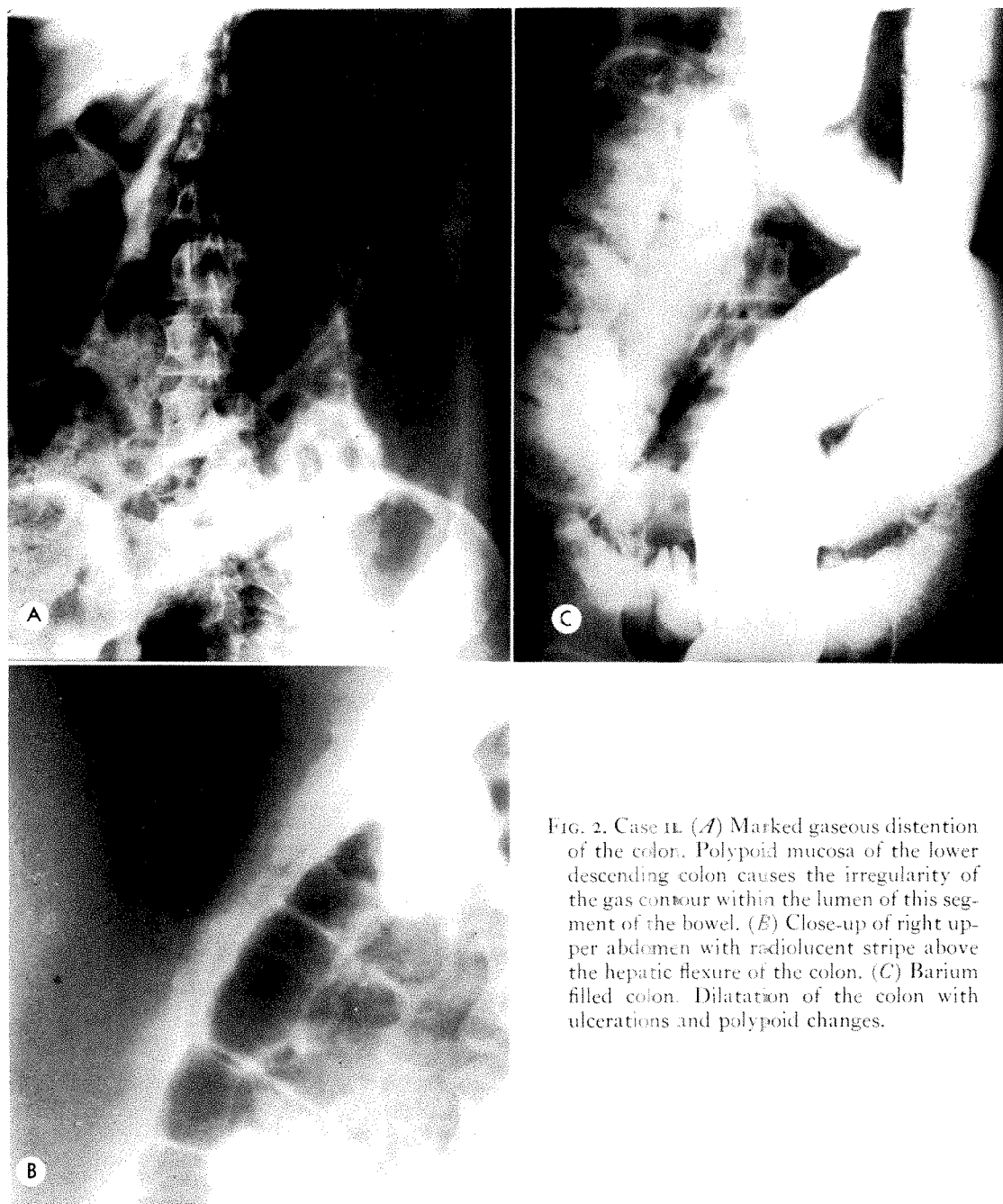


FIG. 2. Case II. (A) Marked gaseous distention of the colon. Polypoid mucosa of the lower descending colon causes the irregularity of the gas contour within the lumen of this segment of the bowel. (B) Close-up of right upper abdomen with radiolucent stripe above the hepatic flexure of the colon. (C) Barium filled colon. Dilatation of the colon with ulcerations and polypoid changes.

postmortem, thrombophlebitis of the popliteal veins and inferior vena cava, bilateral pulmonary emboli and peritonitis were found.

Comment. This case varies from the preceding 2 in that surgery was performed promptly. However, in view of succeeding events, the surgery probably was too ex-

tensive since generalized peritonitis ensued.

Once again, the toxicity, abdominal distention, roentgen findings of the abdomen and left shift of the leukocytes were clues to the diagnosis of dilatation of the colon during an acute exacerbation of chronic intermittent ulcerative colitis.

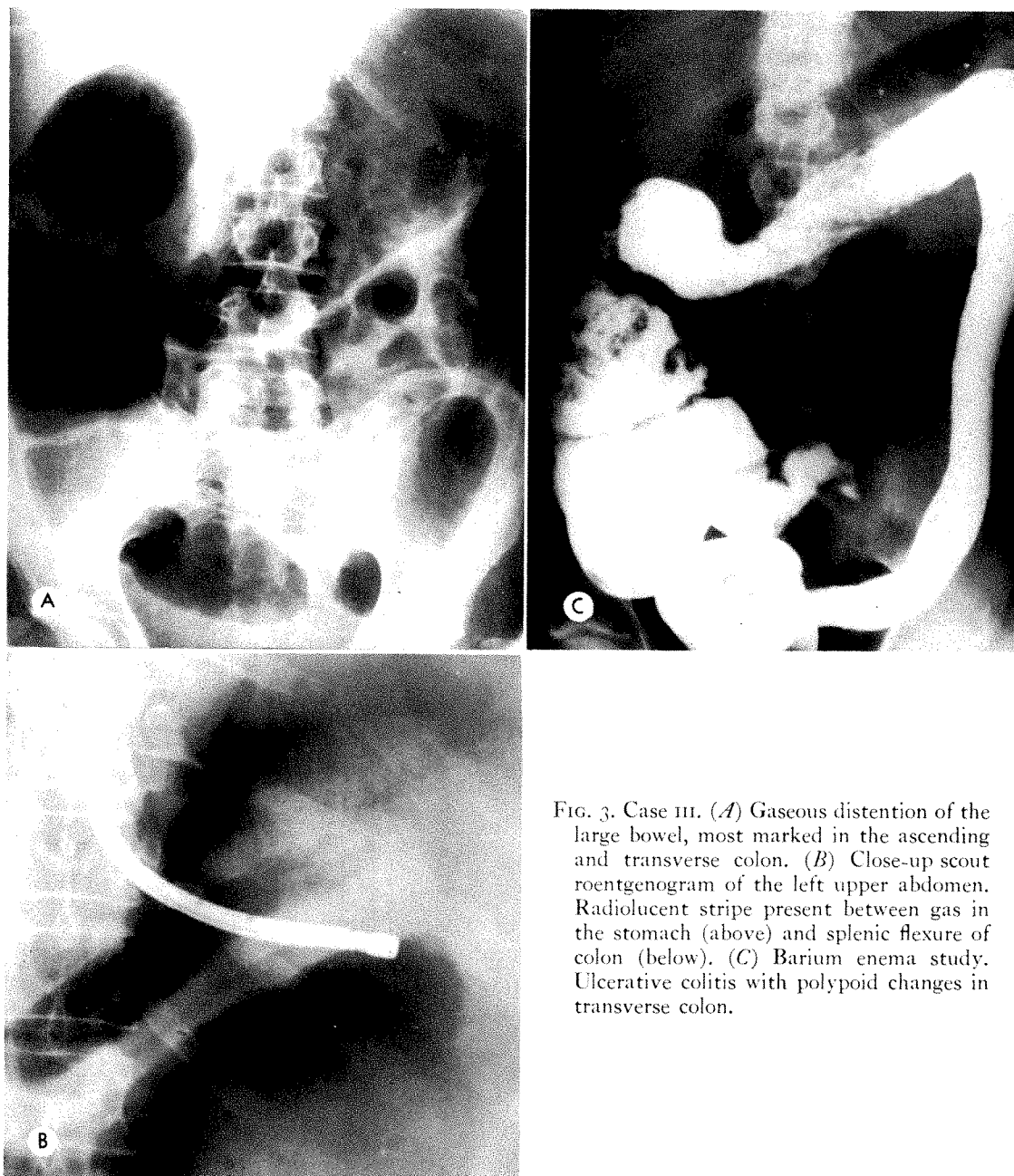


FIG. 3. Case III. (A) Gaseous distention of the large bowel, most marked in the ascending and transverse colon. (B) Close-up scout roentgenogram of the left upper abdomen. Radiolucent stripe present between gas in the stomach (above) and splenic flexure of colon (below). (C) Barium enema study. Ulcerative colitis with polypoid changes in transverse colon.

CASE IV. Patient P.K., Chart #103182 (1/14/59). This sixty-one year old white male was admitted for the first time to Montefiore Hospital complaining of diarrhea. Similar episodes of diarrhea and abdominal pain had occurred for five years before admission. The patient lost 30 pounds in the month prior to his entry into Montefiore Hospital. Examination on admission revealed a blood pressure of

125/75 and a temperature of 98°F., with hypoactive bowel sounds. A proctoscopic examination and a renografin study of the colon revealed changes of ulcerative colitis. Hematocrit was 40 per cent, white blood cell count was 4,600, with a shift to the left. Potassium was 5.4 mEq/L, and the other electrolytes were also normal (Fig. 4, A and B).

The patient was treated medically with

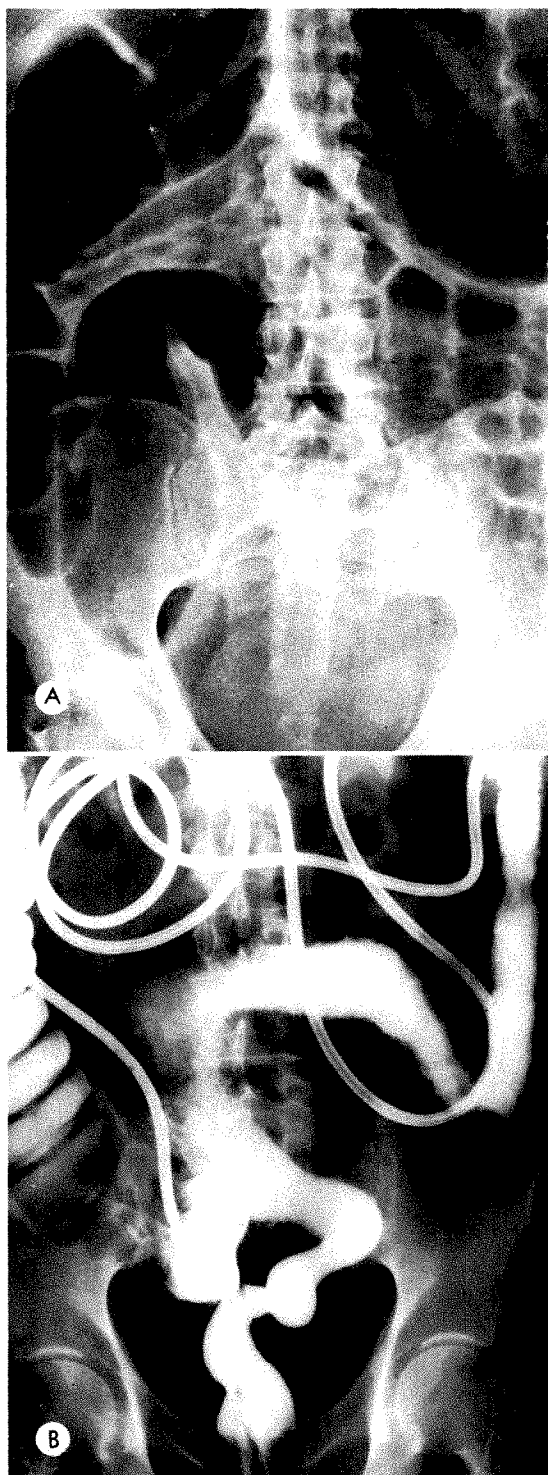


FIG. 4. Case IV. (A) Marked gaseous distention of the colon seen on a plain roentgenogram of the abdomen. Radiolucent stripe below the distal transverse colon. (B) Barium enema study shows ulcerations and polypoid changes in the descending and sigmoid portions of the colon.

fluids and antibiotics. Within five days, abdominal distention, a decrease in bowel sounds and rebound tenderness in both lower quadrants became apparent. Decompression by Miller-Abbott tube and injections of ACTH produced no improvement. Upon exploration, the entire colon was found to be edematous and thickened. A subtotal colectomy and ileostomy were performed eighteen days after admission. The colon was involved by an ulcerating process, most marked in the transverse and descending colon. Microscopic examination revealed the classic picture of ulcerative colitis. Ten days postoperatively, bleeding from the ileostomy was noted, and old blood was aspirated from the stomach. On February 15, 1959, icterus developed. The bleeding episode was considered most likely due to a gastric or a duodenal ulcer, though an erosion of the esophagus due to long term intubation could not be excluded. Twenty-four days after the original surgery, an abdominal-perineal resection was performed because of gross massive bleeding from the rectal stump. The patient's course was further complicated by multiple fecal fistulae and he died of peritonitis seventy-six days after admission.

At postmortem examination, *E. coli*, *Staphylococcus albus haemolyticus* and *Proteus* were cultured from the peritoneal cavity. No ulceration was noted in the stomach, esophagus or duodenum.

Comment. This patient's course varies somewhat from the previously described cases. The signs pointed more toward an acute perforation. The death of this patient was due in part to the failure to recognize the implications of the colonic dilatation and possibly to the too extensive surgery, resulting in the development of the fatal diffuse peritonitis.

CASE V. Patient D.S., Chart #85734 (11/18/56). This thirteen year old boy was admitted to Montefiore Hospital for the first time with an acute history of four to six weeks of bloody diarrhea and an 8 pound weight loss. A proctoscopy revealed a friable, hyperemic rectal mucosa, with multiple bleeding points. Barium enema examination demonstrated a narrowing of the rectum typical of ulcerative colitis. Five days after admission, he was started and maintained on steroids. In the Fall of 1957, the patient had a re-exacerbation of the colitis and was admitted to another hospital because

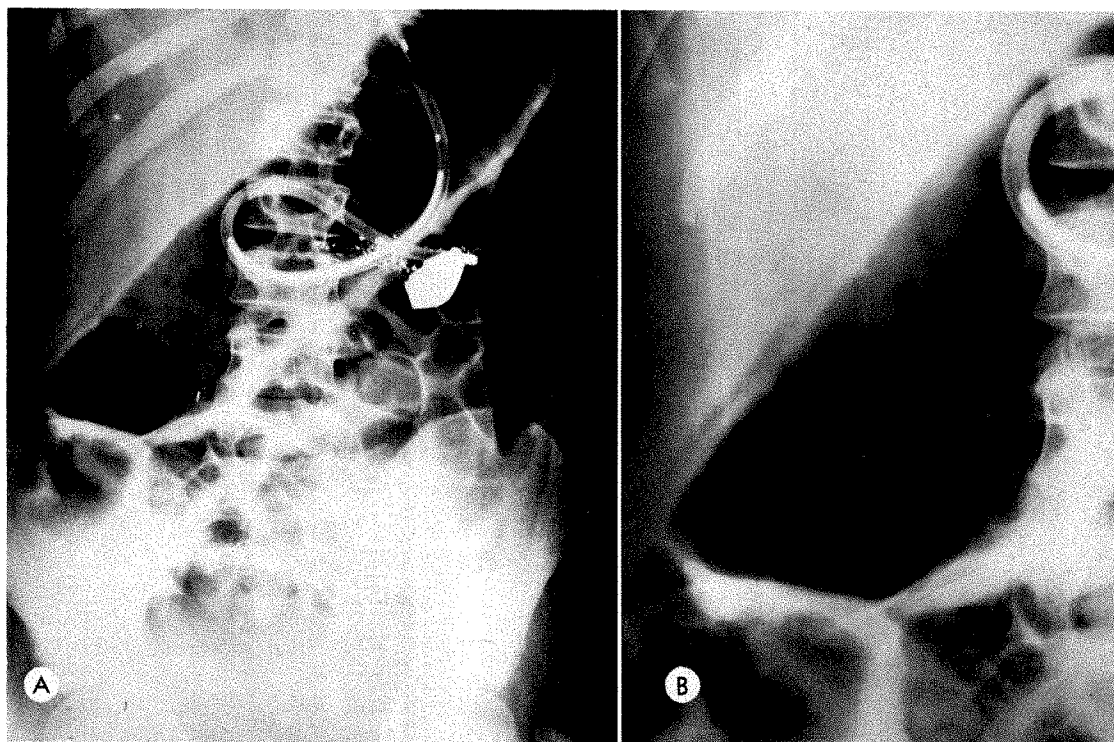


FIG. 5. Case v. (A) Scout roentgenogram of abdomen. There is considerable gaseous distention of the transverse and descending portions of the colon. Radiolucent stripe is present above the hepatic flexure of the colon. (B) Close-up view of A showing radiolucent stripe above hepatic flexure. Irregular gas outline of the upper wall of the hepatic flexure due to polypoid changes in the mucosa.

of severe abdominal distention with colonic dilatation. He was successfully treated with intravenous fluids, a Miller-Abbott tube and prednisone (Fig. 5, A and B).

Comment. This patient was treated successfully by long tube intubation, steroids, and other supportive therapy, permitting a successful colectomy at a later date. Although this patient was not so acutely ill as the preceding four, the case demonstrates that treatment can be successful by medical management even during the phase of colonic dilatation.

CASE VI. C.R., Chart #113719 (4/18/60). This sixty year old white male was admitted to Montefiore Hospital for the first time with a ten month history of watery, bloody bowel movements. Five weeks before this admission, he began to have severe epigastric pain. A gastrointestinal series six weeks before admission revealed a small ulcer on the lesser curvature of the stomach. During this five week period, the diarrhea recurred, and he lost 40

pounds. There was a marked change in his personality from that of an aggressive, hard-driving, extroverted businessman to an obsequious, ingratiating, completely dependent person. On admission, blood pressure was 110/80, temperature 99.6°F, and pulse 120. There was evidence of a marked weight loss and chronic illness. The abdomen was diffusely tender with somewhat hypoactive bowel sounds. Sigmoidoscopic examination revealed a friable, edematous, hemorrhagic, granular mucosa with pseudopolypoid formation. Hematocrit on admission was 47 per cent, dropping to 32 per cent within forty-eight hours after hydration. Serum potassium was 7.1 mEq/L. Steroid therapy was begun on admission and continued during the hospital stay. Forty-eight hours after admission, abdominal distention was noted. Abdominal roentgenograms revealed subserosal air with the classic findings of ulcerative colitis on the plain roentgenograms (Fig. 6, A, B and C).

Three days after admission, an exteriorization cecostomy was performed. For the next several days, the patient was maintained on

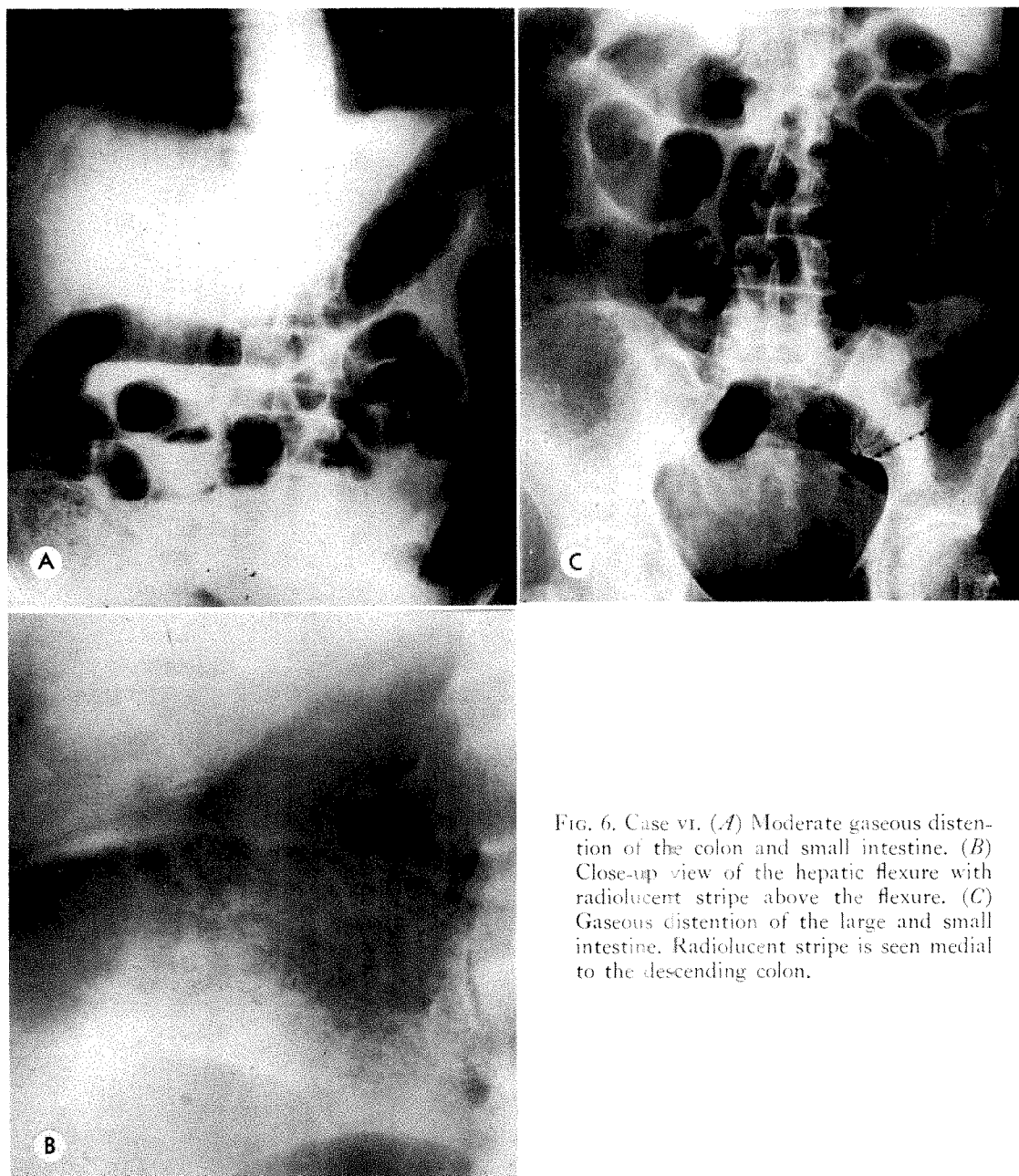


FIG. 6. Case VI. (A) Moderate gaseous distention of the colon and small intestine. (B) Close-up view of the hepatic flexure with radiolucent stripe above the flexure. (C) Gaseous distention of the large and small intestine. Radiolucent stripe is seen medial to the descending colon.

gastric aspiration and electrolyte replacement was determined from serum levels and losses in urine, cecostomy and gastric drainage. Six days after the original surgery, the patient was found to have marked abdominal distention and tympany, with absence of liver dullness. Roentgenograms revealed a huge amount of free air, with considerable gastric distention. No air was seen in the colon. At re-operation, a perforated gastric ulcer was sutured. The

peritonitis present at the time of cecostomy had now subsided. He was continued on steroids, with fluid and electrolyte replacement. Following an elective colectomy six months later, he died from proved peritonitis secondary to a leak from the ileostomy wound.

Comment. This particular case was recognized promptly as a pre-perforative peritonitis and was treated as such.

The rapid institution of surgery after an intensive brief trial of medical therapy, combined with a limited surgical procedure (cecostomy), probably enabled this patient to at least survive the acute illness.

This patient made a good temporary recovery and was re-admitted to Montefiore Hospital on January 3, 1961, for total colectomy, as further studies revealed marked colonic pathology. He had a six month interval of weight gain and relative well-being. Seven days after this elective surgery of total colectomy, he died from overwhelming peritonitis.

CASE VII. Patient J.R., Chart #116488 (8/31/60). This was the second Montefiore Hospital admission of a twenty-nine year old housewife with the complaint of high fever and prostration. The patient had a six month history of diarrhea, fever and abdominal cramps. The patient was admitted to this hospital early in August with a five day history of fever and diarrhea. However, stool and blood cultures were negative. She was treated with antibiotics and ACTH with a resultant fall in temperature, and was discharged on a small maintenance dose of prednisone. Shortly after her discharge, the fever recurred, prompting re-admission. Examination revealed a temperature of 106°F., a pulse of 130, and a distended, diffusely tender abdomen. Her hematocrit was 32.5 per cent, with a white blood cell count of 5,000 with a left shift. Barium enema examination on admission revealed spasm of the entire large intestine, and multiple minute mucosal ulcerations. However, the distal sigmoid, colon, and rectum appeared to be fairly normal. In addition, there was backwash ileitis. The patient continued to have diarrhea accompanied by occasional bloody stools. Sigmoidoscopy revealed a granular mucosa. She was placed on intravenous ACTH and on prednisone. On September 25, 1960, she developed severe, lower abdominal pain and a decrease in the number of bowel movements. Examination of the abdomen revealed moderate distention, with marked tenderness in the right lower quadrant and a suggestion of rebound tenderness. Roentgenograms of the abdomen now disclosed distention of the large bowel throughout, with a radiolucent stripe paralleling the colon. A cecostomy was performed on

September 25, 1960, following which the patient improved and the abdomen became soft. Two or three weeks later, abdominal cramps and fever recurred. She also developed pyoderma gangrenosum. In view of the failure to control the disease by cecostomy alone, a subtotal colectomy and ileostomy were performed on November 4, 1960.

The pathologic specimen showed the external surface of the bowel to be intact. The mucosa of both ileum and colon revealed large areas of ulceration alternating with areas of mucosal hyperplasia. Also noted were several small polypoid lesions which were felt to represent pseudopolyps as seen in ulcerative colitis. The wall of the bowel appeared to be thickened and in some areas reached a thickness of 5 cm. Sections through both lines of resection failed to reveal the ulcerations. The patient was continued on supportive medical treatment including steroids, gradually improved and was discharged.

Comment. This particular case varies from all others in that the character of the disease was again somewhat different. The case probably fits into the so-called segmental type of colitis; however, the complications that were experienced were quite similar to those in patients with universal ulcerative colitis. In this patient, the cecostomy accomplished the early decompression of the bowel and may have been a life-saving procedure. However, by itself it was insufficient to arrest the disease; consequently, it became necessary to remove the center of the infection which resided in the large bowel. Thus, this particular case varies in 2 aspects: (1) in the extent and involvement of the diseased areas of the colon and (2) in the necessity of quickly following the cecostomy with a second more definitive procedure.

It might be argued that cecostomy should not have been performed but that an immediate subtotal colectomy should have been done. The effects of performing an immediate, large surgical procedure in this particular case are speculative. However, if our previous cases can be used as a guide then it seems likely that difficulty might have been encountered if the large

definitive procedure had been attempted immediately.

RESULTS OF OBSERVATIONS

The cases presented indicate that neither the age of the patient (fourteen to sixty-one years) nor the duration of ulcerative colitis (ten months to twenty-five years) was of significance. The more common features in patients with this complication of severe ulcerative colitis are: the presence of peritoneal signs such as abdominal distention and tenderness, associated with toxicity and a shift to the left in the leukocyte series. It appears that this combination of events heralds an extension of the disease process into or through the muscular layers of the colon. The permeability of the bowel is increased and its contractility is impaired; colonic dilatation probably occurs because of loss of muscle tone and the associated peritonitis. The peritonitis is ascribed to increased mucosal permeability, a phenomenon referred to as "durchwanderung" peritonitis.

The grave prognostic signs of acute dilatation of the colon in ulcerative colitis were not appreciated in our first 4 reported cases. The patients' deaths were caused by prolonged and unsuccessful medical therapy, or a subsequent surgical procedure (subtotal colectomy) that was too extensive in the face of a localized peritonitis.

At surgery, all were found to have perforations with large pericolic abscesses predominantly in the descending colon. Although these patients survived the immediate subtotal colectomy and ileostomy, they died at intervals ranging from nine to eighty-eight days postoperatively as a result of overwhelming peritonitis and accompanying complications. It came to be appreciated that the characteristic roentgen finding and clinical picture indicated the presence of "durchwanderung" peritonitis as a prelude to the actual and acute anatomic perforation. These criteria were recognized in Cases VI and VII as indications for imperative surgery. It was neces-

sary to re-explore one patient's (C.R.) abdomen because of a perforated gastric ulcer six days after a decompressive cecostomy had demonstrated a "durchwanderung" peritonitis. At the second exploration, this peritonitis was no longer evident. It would appear that simple decompression of the bowel restored its integrity, at least as far as permeability is concerned.

All our patients received steroids in the pre-dilatation stage of the disease. One patient who received no steroids had distention prior to the institution of steroids. The acuteness of the illness was not usually reflected by the patients' subjective complaints. These complaints were essentially that of marked weight loss, without any aggravation of their previous tenesmus and bloody diarrhea. In our patients, the weight loss ranged from 30 to 40 pounds in a period of eight to twelve weeks. It is of interest that significant rectal bleeding was rarely noted during the phase of acute dilatation. The severity of the inflammatory process was indicated by a marked shift to the left of the leukocyte series, with toxic granulations. Serum potassium levels were normal, but these levels do not necessarily reflect the total body potassium stores.

In all cases, there was one constant feature, the diagnostic roentgen sign as seen in the plain roentgenograms of the abdomen.

ROENTGEN FINDINGS

Simple roentgenograms of the abdomen are of considerable importance in the roentgenographic diagnosis and evaluation of ulcerative colitis.^{7,14} This type of examination is innocuous and can be performed without risk even in the most seriously ill patients. Correct interpretation of the abdominal roentgenograms without the use of opaque contrast media frequently provides information indicating the extent, severity and complications of the disease. The findings present prognostic implications suggesting the therapeutic approach.

In patients with ulcerative colitis and acute dilatation of the colon, a barium

enema study may be contraindicated since destruction and thinning of the colonic wall could permit barium to enter the peritoneal cavity. Even when performed, the poor mixing of the contrast medium and colonic gas and fluid often result in an unsatisfactory examination.

Adequate roentgenograms of the abdomen should be obtained in various positions. Supine and prone positions are necessary to shift the location of gas and fluid within the intestine, especially in the colon. Horizontal beam, erect lateral decubitus and transabdominal roentgenograms, although most valuable for the detection of free intraperitoneal gas and gas fluid levels, may improve the air contrast studies of the entire colon by shifting gas and fluid within the bowel.

Small quantities of gas are usually present in segments of the normal colon and serve as a negative contrast substance. This outlines the normal haustral pattern of the colon, indicating the normal bowel caliber. The normal colonic motility results in a varying gas pattern with intervals of time. Gas fluid levels are not encountered in a normal colon but occur following cleansing enemas and functional states with hypermotility of the small intestine. The pericolic fat, seen as a radiolucent longitudinal stripe, outlines the outer wall of the colon. Thus, the bowel wall thickness can be measured between the intraluminal gas and the pericolic fat.

Changes in the gas pattern of the colon as seen on the plain roentgenogram of the abdomen commonly reflect the pathologic findings of ulcerative colitis. Fluid retained in the large bowel is the result of mucosal inflammation and hypermotility of the colon with impaired resorption. Long gas fluid levels are seen on the horizontal beam roentgenograms. A change in the distribution of gas and fluid is visualized on the horizontal prone and supine roentgenograms. Excessive colonic gas is said to result from an increase in intestinal fermentation and from the blood stream, associated with stasis.¹⁴ This gas will distend the colon

and diminish the haustral pattern. The most marked distention is usually noted in the transverse colon. Loops of distended small intestine are frequently seen, but the distention is less marked than in the colon. Ulcerations are visible as projecting spikes in the intraluminal gas pattern. Additional findings may include shortening of the colon and a paucity of fecal material in the right side of the colon. The shortening of the colon has not been a frequent finding in this series or in those reported by others. The hepatic, splenic, and sigmoid flexures are well maintained. Pseudopolypoid and true polypoid lesions may be seen in profile or *en face* as nodular, irregular soft tissue densities projecting into the intraluminal gas column. These polypoid lesions are usually most evident in the transverse colon. Irritability may be manifested as segmental narrowing of the gas column. When the thickness of the colon wall is altered, this can be demonstrated as a decrease or increase in the distance between the intraluminal gas and the pericolic fat stripe. We have, however, been somewhat skeptical of the frequency with which the fat stripe would persist in patients with chronic ulcerative colitis where there is a loss of general body fat, including fat within the abdomen. We have, therefore, concluded that the radiolucent stripes seen in patients with ulcerative colitis (Fig. 1 *A*, 2*B* and 3*B*) and acute dilatation of the colon (Fig. 4*A* and 5*A*) may reflect a submucosal accumulation of gas secondary to intramural fistulization resulting from an increased permeability of the diseased mucosa. Such extraluminal gas may be seen as irregular stripes (2-4 mm. in thickness) of radiolucency in the bowel wall. These air collections must be distinguished from the presumably normal pericolic fat stripe which is usually thinner, longer, more regular and continuous. The development of peritonitis, localized or generalized, will alter the roentgen findings. The accumulation of intraabdominal fluid will cause separation of loops of bowel as well as distention of the entire gastrointestinal tract.

Complete perforation of the colon results in pneumoperitoneum. However, if the perforation occurs below the level of the peritoneal reflection, in the distal colon or around the posterior wall of the colon in any portion of the colon, retroperitoneal emphysema occurs. Subserosal collections of gas may be expected in perforations which are not complete. The presence of pericolic adhesions can result in a localized perforation either within the peritoneal cavity or in a subserosal position. The presence of localized perforation has been much more difficult to detect. Streaks of gas may be seen at the site of a localized perforation.

Serial roentgenograms of the abdomen may disclose significant changes in the pattern of ulcerative colitis before they are apparent clinically. This is particularly true in those patients with acute dilatation of the colon where the clinical signs and symptoms may lag behind findings on the simple roentgenogram of the abdomen.

SURGICAL MEASURES

Surgical measures for acute episodes in the course of ulcerative colitis have always been associated with high morbidity and mortality. For the most part, such urgent intervention is necessary for the control of perforation or uncontrollable bleeding or systemic toxicity. The surgical aim is to divert the intestinal stream and to resect the colon which is the source of the perforation, bleeding or sepsis.^{1,11} It has been the general experience that, when the disease has progressed to this stage, the colonic changes are rarely reversible. The unsatisfactory surgical results in the above acute complications were most often due to a delay in instituting the procedure, as well as to the magnitude of the surgical intervention. Such patients, already exhausted by the ravages of the disease, are in the worst condition for the necessary surgery. Ileostomy, as the sole procedure, has been unsatisfactory because it does not remove the colonic source of the complication. A more satisfactory approach entails colectomy

and ileostomy in one stage. The distal extent of the resection is determined at surgery; it may extend to the sigmoid or to the anus via the anterior approach without requiring a perineal phase.

The situation in acute dilatation of the colon with toxicity differs from the usual indication for emergency surgery in fulminating ulcerative colitis. Because it is possible to recognize, in this stage of the disease, a preperforated phenomenon, and because this even may be at least temporarily reversible, the surgical procedure may, therefore, be conservative. This surgical conservatism is dictated by the fact that the aim is not to eradicate the disease at this time but to tide the patient over an acute incident in its course. Conservatism is also indicated because our own experience with colon resection in the presence of perforative peritonitis has been totally unsatisfactory. A one stage colectomy with ileostomy is mandatory when free perforation has occurred because it is impossible to suture the perforation satisfactorily and to drain the area. The usual problems of peritonitis are further increased by the fact that the bowel wall is friable, thin and distended so that it is easily damaged during resection, and surgical spillage aggravates the pre-existing peritonitis.

In the stage of acute dilatation with toxicity, a cecostomy or ileostomy may achieve the desirable end of decompressing the colon with a minimum of handling.⁴ The cecostomy may be done under local or spinal anesthesia through a McBurney incision. A tube cecostomy is somewhat dangerous since it is not always possible to reliably suture the edematous, ecchymotic wall to the abdominal parietes. An exteriorization cecostomy eliminates this danger, although it poses future problems regarding the uncertainty of its spontaneous closure. The urgency and gravity of the situation do not make this latter fact a too important consideration. Cecostomy may achieve the purpose of providing a vent for air and feces sufficient to produce a partial restoration of the integrity of the

bowel wall and to decrease its permeability. Although this is an old and previously discarded method of treating ulcerative colitis in general, it may be logical to utilize this method for the treatment of this specific complication, as a temporizing measure. Similarly satisfactory experiences have been reported by others.

Ileostomy also serves to bypass the fecal stream from the diseased colon, though its effectiveness as a vent in this complication of ulcerative colitis remains to be demonstrated.

Neither procedure eliminates the possible need for subsequent colectomy, since these approaches are not directed at the fatal disease, but at one of its acute complications.

DISCUSSION

The evaluation of the published experience with this complication is difficult because prior to its recognition as a distinct entity, these cases were considered with cases of fulminating ulcerative colitis. This latter group included all patients with acute manifestations of the disease as evidenced by massive bleeding, perforation and toxicity. Acute dilatation of the colon with toxicity deserves to be recognized as a distinct entity within the broad group of fulminating ulcerative colitis because of the distinct clinical and roentgenographic findings resulting from the altered permeability of the large bowel.

In 1951, Crile and Thomas¹ reported 31 cases of acute toxic ulcerative colitis. However, their criteria for including these patients in this category were sustained fever and persistent tachycardia. It was noted that patients in this group often had distended and atonic colons, but no clear-cut comparisons to our patients can be drawn because of the heterogeneity of their patients.

The role of steroids in the development of this entity is difficult to ascertain. Although all of the patients in our group received steroids prior to or during the onset of colonic dilatation, other series have in-

cluded patients who never received such therapy.

In Lumb and co-workers'⁵ series of 7 patients, only 1 of the 5 surgically treated was given steroid therapy. Roth *et al.*¹² used steroids in 5 of the 12 reported patients. Of these 5, 2 received medical and 3 surgical therapy, with only 1 postoperative death. An additional 5 of 7 patients survived without steroid therapy. Similarly, 6 of 9 surgically treated patients in Peskin and Davis's⁹ series were given steroids. One half of these patients survived, while all 3 not receiving steroids survived. The largest group of patients receiving this type of replacement therapy was reported by Marshak *et al.*⁷ Of their 16 patients, 11 underwent surgery and 5 were treated medically. Two of the 3 medically treated patients receiving steroids survived and of the 11 surgically treated patients receiving steroids, 10 survived.

It is impossible on the basis of these reports and our own experiences to assess the role of steroid therapy definitively either in initiating or in aggravating the pathologic state resulting in the clinical picture under discussion.^{3,6,7,9,10,12}

It appears that steroids may be tried for a short period of time in the hope of reversing the picture of acute dilatation of the colon. However, prolonged use of steroids in the presence of dilatation of the colon without a surgical or tube decompression may only accelerate the "durchwanderung" peritonitis.

This previously described roentgen sign should be used as a guide in diagnosis and therapy. The continued presence of this sign accompanied by dilatation means that medical therapy must be supplemented by immediate decompression of the bowel. This decompression has been successful by long tube intubation or surgery.

All patients with this disease entity require extensive electrolyte replacement despite apparently normal serum electrolytes. The existence of a preperforative or actual peritonitis makes the use of broad spectrum antibiotics mandatory, either

with or without steroid administration.

We have observed the occurrence of upper gastrointestinal bleeding in patients with acute ulcerative colitis and dilatation of the colon. It had previously been the experience that patients with ulcerative colitis rarely develop peptic ulcers, even when on steroids.³ However, in our series of 7 cases, we encountered 1 perforated gastric ulcer and 1 instance of upper gastrointestinal bleeding without a demonstrable source. In the series of 9 patients reported by Peskin and Davis,⁹ the problem of upper intestinal bleeding also was present. One patient required a subtotal gastrectomy for upper gastrointestinal bleeding. A second bled via the ileostomy with the site or cause of bleeding not definitely determined. Nevertheless, it is possible that patients with this particular complication of ulcerative colitis have a slightly higher incidence of upper intestinal bleeding, due to peptic ulceration.

Thromboembolic phenomena were encountered in 2 of our cases. Pulmonary infarcts were noted in these cases as well as extensive venous thrombosis and thrombophlebitis. We are not certain of the exact meaning of this phenomenon. It is possible that this represented a preterminal series of events or a part of the disease itself.

It is of interest that in the 52 reported patients with acute dilatation of the colon, including our own, not a single case of carcinoma of the colon was described, even though many had long standing disease.

The clinical picture observed in our patients was that of severe toxicity, malnutrition secondary to poor food intake, dehydration, electrolyte depletion and peritonitis. Although the subjective symptoms were commonly deceptive by their apparent mildness, the obvious toxicity and abdominal distention were indicative of the severity of the disease process at the time the patients were seen.

The importance of frequent plain roentgenograms of the abdomen as an indication of the onset of colonic dilatation cannot be overemphasized. A retrospective study of

the course of the 4 patients who died revealed the presence of the diagnostic colonic subserosal air line during the time when the clinical signs alone were deceptive and the gravity of their illness was not fully appreciated. This roentgenologic sign has served as an important guidepost in the recognition of early colonic dilatation in the other patients with a resulting marked improvement in their clinical course. Whether long tube intubation or surgery is to be employed as a mode of therapy once colonic dilatation has occurred is still not clearly settled. Whether this should be a cecostomy or ileostomy cannot be stated in view of our limited experience and the heterogeneity of published results. All facets of medical care should be continued regardless of the procedure of choice relating to the specific problem of the colonic dilatation.

SUMMARY

1. Acute dilatation of the colon with toxicity is a distinct entity within the spectrum of fulminating ulcerative colitis.
2. This complication may be suspected in the presence of abdominal distention when associated with tenderness and leukocytosis.
3. The characteristic roentgen sign of preperforative acute dilatation of the colon is the presence of a zone of translucency outlining the serosal border of the distended colon.
4. These findings indicate a preperforative or perforative peritonitis which requires urgent decompression.

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DIFFUSE LYMPHOMATOUS DISEASE OF THE COLON: ITS ROENTGEN APPEARANCE*

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THIS is a study of the roentgen appearance of diffuse lymphomatous involvement of the colon. Primary, localized lymphoma of the large bowel is rare,^{15,31,38,42,46} although secondary localized involvement of the gastrointestinal tract may occur not infrequently during the course of malignant lymphoma.^{15,20,38,41,44} The colon was found to be involved (clinically and at autopsy) in 84 patients in a group of 1,269 cases of lymphosarcoma.³⁸ However, the involvement of the entire colon by lymphosarcoma and related diseases is a very unusual occurrence. Consequently, diagnostic criteria for its recognition have not yet been established, nor has a complete review of the reported cases in the literature been undertaken from the standpoint of roentgen diagnosis. The radiologist and the clinician must become aware of the existence of this diffuse form of colonic involvement in order to arrive at the correct diagnosis and thereby instigate proper management.

REVIEW OF THE LITERATURE

CLINICAL FEATURES

Careful review of the literature disclosed 45 instances of diffuse involvement of the colon by malignant lymphoma.^{2,5-14,19,22,24,26,27,33,35-37,39,43,45,48,49,51,52} Of these, including all cases classified as "pseudoleukemia intestinalis,"^{2,5,12-14,45,49} 35 are almost undoubtedly examples of lymphosarcoma. Five were diagnosed as chronic lymphatic leukemia,^{6,9,24,26,33} 3 as Brill-Symmers disease^{2,11,49} and 2 as reticulum cell sarcoma.^{11,37}

There were 24 males and 13 females in the total group of 45 cases, a finding which agrees with the known predominance in

males of lymphosarcoma of the gastrointestinal tract.^{1,3,15,38,44} The sex was not stated in 8 cases. The youngest patient was five years old¹² and the oldest seventy-five;¹¹ most were in the fifth decade. The most common complaint was diarrhea, noted in 17 cases.^{5,7,10,11,14,22,23,35,36,43,45,49,51} Bloody stools were recorded in 11.^{5,7,11,14,33,36,43,45,49} The duration of symptoms varied from twelve days⁵ to three years¹² with an average of approximately one year. Splenomegaly was described in the majority^{6,7,9,11,13,22,24,33,35,36} and generalized or peripheral lymphadenopathy was seen in 20.^{5-7,9,11,13,22,24,26,33,35,37,45,49}

Of these 45 cases of diffuse involvement of the colon by malignant lymphoma found in the literature, 35, or more than three-fourths of the total, also showed invasion of other segments of the alimentary tract. The stomach was involved in 27 patients^{2,5-11,13,24,27,35,36,39,45,49,51} and the small bowel in 31 cases.^{2,5-7,9-14,24,26,27,33,35,36,39,43,45,49,52} Both stomach and small bowel invasion, in addition to the disease in the colon, were present in 60 per cent. Twenty-three of the 45 reported cases came to necropsy.^{5-7,9,11,13,14,24,26,33,35,37,39,45,49}

One of the earliest reports was that of Bricquet in Cruveilhier's¹³ atlas. The gastrointestinal tract appeared to be invaded with innumerable polypoid lesions, "as large as the point of the little finger" throughout the entire colon, but with otherwise normal appearing mucous membranes. The entire gastric mucosa was thrown into heavy, sinuous folds which resembled "cerebral convolutions."

Six of the cases described by Wells and Mayer⁴⁹ showed polypoid lesions in the colon which ranged from pea size to the

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size of chestnuts, countless in number. Extensive slightly elevated patches, some being pigmented slaty black, were noted. The mucosal surface, however, appeared normal and ulcerations that were present were usually slight and superficial. The increase in tissue was limited to the mucosal and submucosal coats, the muscularis not being invaded to any extent. The same authors also remarked that, in spite of enormous thickenings, the lumen of the bowel was not altered in size. Numerous pea sized, polypoid growths were noted in the small bowel, which also showed extensive infiltrations of Peyer's patches. The stomach in most of the cases revealed a "cerebriform" appearance due to "immense, loose mucosal folds."

The case described by Symmers⁴⁵ showed literally thousands of closely aggregated, pale, rounded, nodular projections varying in size from that of a millet seed to a split pea. Many of them presented small crater-like depressions at the summit. There were massive folds throughout the colon, especially in the cecum, where they formed a mass 4 cm. in height. There was also diffuse involvement of the stomach and small bowel. The cases described by Russell,³⁹ Borgida *et al.*,⁷ Reifenstein,³⁵ Pearson *et al.*,³⁸ de Jongh,¹⁴ Boikan,⁶ Ikeda,²⁴ Adams-Ray and Sundström,² Cornes¹¹ and Cosens¹² fall into the same general pattern as the ones reported above.

Winkelstein and Levy⁵⁰ studied the sigmoidoscopic appearance of cases of lymphosarcoma of the colon and described a typical "hill and valley" appearance with polypoid lesions and prominent folds resembling the convolutions of the brain. The mucosa may be reddened, with occasional superficial ulcerations, and it may be covered with patches of white exudate. This general appearance was noted in practically all instances in which sigmoidoscopy was performed.^{2,7,9-12,19,35-37,48,51} However, in 1 case³⁶ the appearance was thought to represent an atypical ulcerative colitis, and in another case¹⁰ it was interpreted as diffuse polyposis of the colon.

ROENTGEN FINDINGS

Roentgenographic reproductions were published for 18 of the 45 cases^{2,7,8,10,12,22,27,35-37,52} and a description of the roentgen findings was presented in others.

Innumerable diffuse polypoid lesions were described in all cases. They usually varied in size from a few millimeters to 2 or 3 cm.; occasionally they were even larger. They appeared as elevations in bas-relief and were not pedunculated. However, an example of a pedunculated lymphomatous polypoid lesion was published in the recent paper of Cornes.¹¹ Robert *et al.*³⁶ described the typical "soap-suds" appearance and the "honey-combed" pattern of the lesions based on their experience. These configurations could be seen in most of the pictured colon examinations. Wolf and Marshak⁵² noted the increased width of the lumen of the colon and its failure to significantly contract on postevacuation roentgenograms. This feature was also evident to us in most of the roentgenographic reproductions. None of the cases displayed segments of narrowing or obstruction. Usually the mucosal folds seemed markedly enlarged producing a coarse, reticulated appearance. There was also thickening of the bowel wall, which usually showed an irregular, shaggy inner contour with multiple wavy serrations. The colon seemed to distend well in cases in which air studies were performed.

When the stomach was simultaneously involved, the roentgen studies of this organ revealed a typical thickening of the mucosal folds forming "giant rugae" which had a cerebriform appearance.^{2,8,10,38,39,50,51} The disease spread in continuity into the duodenum in several cases.^{2,10,24,27,36}

Small bowel studies demonstrated the presence of multiple polypoid lesions in a few instances.^{10,27,36,52}

TREATMENT

Radiation therapy to the abdomen, either alone or in conjunction with chemotherapy, or chemotherapy alone was given to 18 patients.^{2,7,8,10-12,19,22,33,37,39,43,48,51,52} Practi-

cally all of these patients showed good clinical response to therapy. In 8 follow-up barium enema examinations, all revealed obvious regression or total disappearance of the polypoid lesions following treatment.^{8,10,22,37,51,52}

Resection of the colon was performed in 2 cases^{11,12} before the pathologic diagnosis of diffuse lymphomatous disease of the colon was established, based on the clinical impression of multiple polyposis of the colon.

According to Sugarbaker and Craver,⁴⁴ who reviewed 196 cases of lymphosarcoma, extension into the gastrointestinal tract carries a generally unfavorable prognosis. Twenty-seven of the 45 cases of diffuse lymphoma of the colon reported in the literature were followed until their death. The average duration of life after the diagnosis was established was one and one half years.

REPORT OF CASES

CASE 1.* E.S., a thirty-eight year old male, was admitted on October 25, 1955 with a five year history of swelling of the right side of the neck, a biopsy of which revealed lymphosarcoma. Shotty lymph nodes were noted in the right axilla and both groins. Radiation therapy to all affected sites produced prompt regression. Six months prior to admission, enlarged lymph nodes were again discovered in the right groin and the patient developed persistent diarrhea without melena and associated with an abdominal mass in the right lower quadrant. Radiation therapy was then administered to this area. Two months later, nodes became conspicuous in the right periorbital region and these also regressed after irradiation. One month prior to admission he experienced epigastric fullness and a gastrointestinal series revealed delayed emptying of the stomach. Radiation therapy was administered to the epigastrium through anterior and posterior ports.

Physical examination on admission revealed generalized peripheral lymphadenopathy. The liver edge was palpable almost at the level of the umbilicus, and the spleen extended 3 cm.

* A patient of Dr. D. A. Karnofsky.

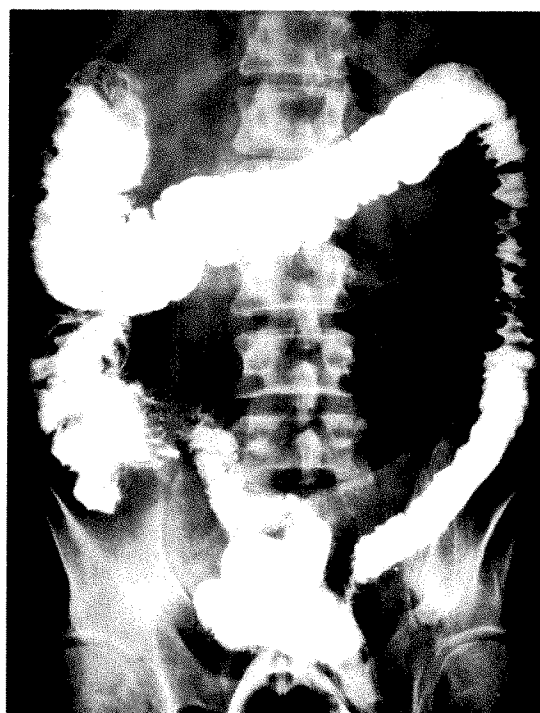


FIG. 1. Case 1. June 20, 1955: Diffuse lymphosarcoma of the colon. Note the worm-like polypoid lesions throughout the colon and the shaggy margins of the bowel.

below the costal margin. Bulging lymphoid masses almost completely filled each nasal cavity posteriorly.

Submitted roentgenograms of a barium enema examination dated June 20, 1955 showed diffuse polypoid lesions involving the entire colon. These defects were wormlike, had a soap-suds appearance and measured from 0.2 to 4 cm. in diameter. The entire large bowel presented a shaggy contour (Fig. 1). There was, however, no constant narrowing and the colon distended well. The terminal ileum also appeared involved for a distance of approximately 10 cm.

At the time of admission, feces were guaiac positive. Sigmoidoscopy revealed a congested, exceedingly friable mucosa, the over-all appearance of which was thought by the examiner to be suggestive of an early, nonspecific colitis. Studies of the peripheral blood were within normal limits. Rectal biopsy was interpreted as a benign colonic mucosa.

From June 22 to July 13, 1955, the patient received roentgen irradiation of the mass in the

right lower quadrant to an amount of 1,000 r in air. He also received 30 mg. of triethylene melamine between August 9 and August 13, 1955.

A barium enema examination performed on October 27, 1955 revealed disappearance of most of the previously seen polypoid lesions in the colon and terminal ileum, although several of these defects were still noted in the descending colon. A chest roentgenogram of October 28, 1955 showed superior mediastinal lymphadenopathy. A gastrointestinal series of October 31, 1955 demonstrated hypertrophy of the mucosal folds of the gastric fundus and antrum and of the duodenum as well, which was considered to be suggestive of lymphosarcomatous involvement.

On October 31, 1955, the patient was started on 100 kv. roentgen irradiation to the entire trunk for a total dose of 370 r. During this treatment, diarrhea improved and there was regression of the affected lymph nodes. A chest roentgenogram of November 8, 1955 indicated regression of the mediastinal mass. The patient then received local irradiation to the popliteal regions and nasopharynx, and was started on prednisone. After completion of radiation therapy, he was discharged.

On May 30, 1956, he was readmitted with recurrent lymphadenopathy in the cervical, right conjunctival and right infraclavicular regions, a right pleural effusion, slight enlargement of the liver and spleen, and a vague central abdominal mass measuring 14 cm. in diameter. This mass received a tumor dose of 240 r, and 300 r was given to both the right infraclavicular mass and the right inguinal region. He also received roentgen therapy to the mediastinum. There was regression of the palpable masses and decrease of the right sided pleural effusion. A barium enema examination done on June 1, 1956 (Fig. 2) showed a normal colon with interval disappearance of all of the polypoid lesions previously reported. The patient was discharged on June 9, 1956. He expired shortly afterwards.

Comment. This is an example of generalized lymphosarcoma with clinical and roentgenologic evidence of diffuse involvement of the entire colon and terminal ileum, and suspicious involvement of the stomach and duodenum. The barium enema showed a typical wormiform and soap-suds

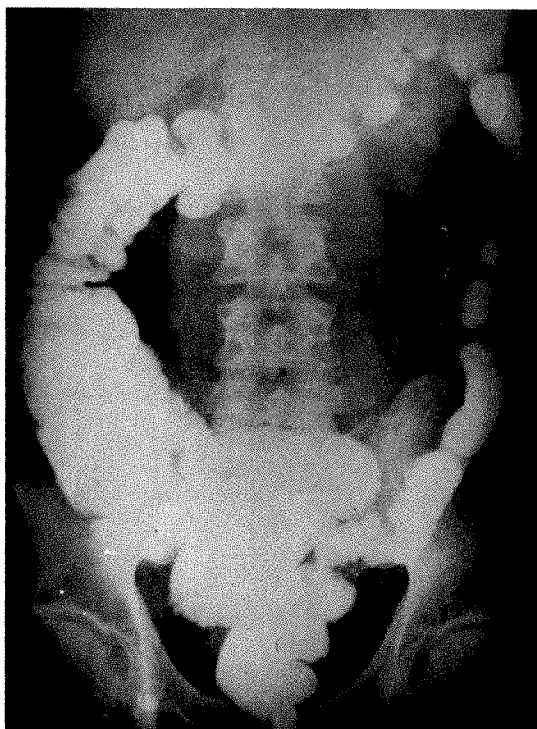


Fig. 2. Case I. *June 1, 1956:* Disappearance of the lesions following radiation therapy and chemotherapy.

appearance of the entire colon. There was good local response to radiation therapy and chemotherapy with complete disappearance of the colonic lesions.

CASE II.* G.A., a forty-six year old white male, was first admitted on August 11, 1954 with a history of abdominal distention for three and one half months, pain in both lower quadrants and episodes of sweating and precordial pain.

Physical examination revealed bilateral supraclavicular, axillary, and inguinal lymphadenopathy. The lymph nodes were smaller than 0.5 cm. except one in the left supraclavicular region which measured 3 cm. in diameter. Several 2 to 4 cm. masses which were palpated through out the abdomen appeared to represent enlarged mesenteric lymph nodes. There was a fullness in the epigastric region and the liver and the spleen were slightly enlarged. Proctoscopy showed multiple mucosal nodules

* A patient from the Lymphoma Service. Reference to this case has been made previously.¹⁵

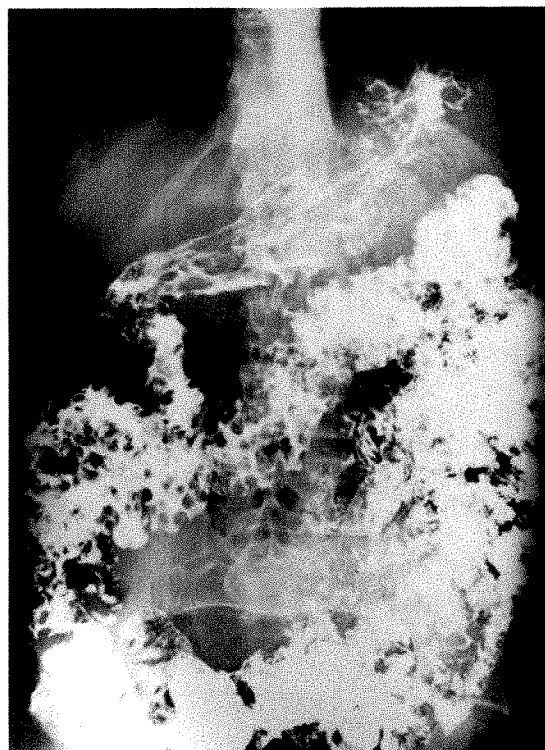


FIG. 3. Case II. August 16, 1954: Diffuse involvement of the stomach, duodenum, ileum and entire colon by lymphosarcoma. The colon is increased in caliber and shows a typical vermiform and soap-suds-like polypoid pattern. Note the cerebriform appearance of the stomach with the duodenum involved in continuity. (Reproduced with permission from *M. Clin. North America*.¹⁵)

beginning at the anal verge and extending up as far as the scope was passed (22 cm.).

The laboratory findings on admission showed: hemoglobin, 14.2 gm.; red blood cells, 5 million; white blood cells, 10,000; polymorphonuclear leukocytes, 41 per cent; eosinophils 1 per cent; lymphocytes, 50 per cent; monocytes, 3 per cent; platelets, 290,000; total cholesterol, 189 per cent; free cholesterol, 64 mg. per cent; bromsulphalein excretion, 4 per cent; protein, 5.6 gm./100 cc.; albumin, 4.1 gm./100 cc. The stool was positive for occult blood.

Chest examination revealed extensive mediastinal and bilateral hilar lymphadenopathy and barium enema examination disclosed polypoid lesions throughout the entire colon. These defects varied from 0.5 to 1 cm. in diameter and presented a honeycomb appearance throughout the entire bowel. The colon was of a large caliber and the post evacuation roent-

genogram demonstrated failure of contractility. Upon air insufflation, the polypoid lesions had a tendency to flatten out, thus becoming somewhat less apparent.

Biopsy of the rectal lesions and of a left axillary lymph node disclosed the presence of lymphosarcoma.

A gastrointestinal series dated August 16, 1954 revealed marked accentuation of the mucosal folds of the entire stomach and duodenum, forming a cerebriform appearance (Fig. 3). This was considered to be due to extensive lymphosarcomatous infiltration. Although the jejunum appeared normal, the terminal ileum presented evidence of involvement.

The patient received radiation therapy from August 19 to August 23, 1954 to the left axilla and to the abdomen, the latter through four anterior and four posterior ports. The left axilla received 900 r, while 600 r was given in air to each of the abdominal ports. He responded well to treatment as evidenced by subsidence of the diarrhea and the abdominal distention and a decrease in the axillary and abdominal lymph node masses. A barium enema examination dated January 4, 1955 showed an almost normal appearance (Fig. 4). An upper gastrointestinal series dated January

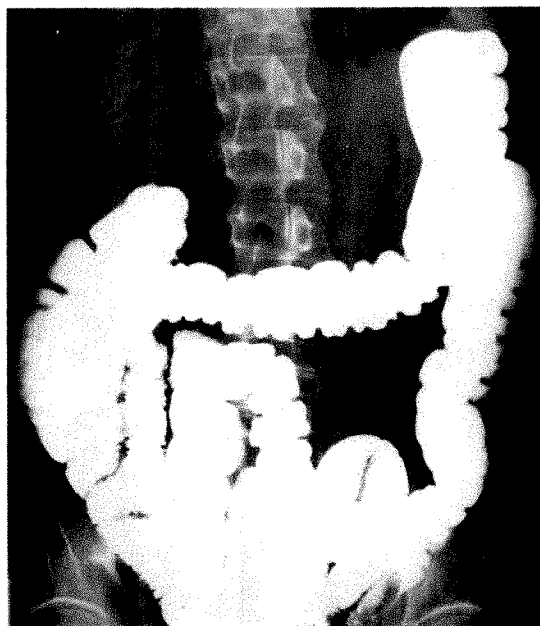


FIG. 4. Case II. January 4, 1955: Almost complete disappearance of the colonic lesions following radiation and chemotherapy. (Reproduced with permission from *M. Clin. North America*.¹⁵)

14, 1955 likewise revealed disappearance of the abnormal mucosal pattern.

The patient was well until May, 1955, when cervical lymphadenopathy and splenomegaly developed. He received 750 r to the right axilla, 1,000 r to the right neck, and 2,000 r to the left neck. There was good remission until October, 1955 when he complained of epigastric discomfort, swelling, dyspnea, weakness, fatigue, and generalized lymphadenopathy. There were hepatosplenomegaly and ascites. A barium enema examination of October 7, 1955 disclosed a recurrence of the polypoid lesions throughout the colon, although not as extensive as previously. A gastrointestinal series, October 11, 1955, again revealed diffuse polypoid infiltration of the entire stomach and duodenum and a chest roentgenogram demonstrated extensive mediastinal and hilar lymphadenopathy. Bone marrow examination of October 10, 1955 showed predominance of large and immature lymphocytes suggesting lymphosarcoma progressing to a leukemic phase.

On October 14, 1955 the patient was given 0.4 mg./kg. of nitrogen mustard for a total dose of 22 mg. He had a good response, marked by regression of the generalized lymphadenopathy and hepatosplenomegaly and a disappearance of his constitutional symptoms. Barium enema examination of November 30, 1955 also showed significant regression of the polypoid lesions since October 7, 1955.

A transurethral resection of the prostate was done on January 11, 1956 because of pronounced prostatic hypertrophy resulting in severe urologic symptoms. The pathologic report of the submitted specimen was lymphosarcomatous infiltration.

The patient received several courses of radiation therapy during 1956 and the first half of 1957 for recurrences of disease. Among the areas treated were the mediastinal, abdominal, cervical, periorbital and inguinal regions. He was also given several courses of nitrogen mustard, prednisone and 5-fluorouracil.

In February, 1957, the white blood cell count was 34,000. The clinical picture was described as that of lymphosarcoma showing clinical metamorphosis to low grade chronic lymphatic leukemia.

The patient expired on June 22, 1957, after developing signs of bilateral bronchopneumonia. Permission for necropsy was not obtained.

Comment. This is a case of diffuse involvement of the entire colon, terminal ileum, stomach and duodenum by generalized lymphosarcoma. The colon showed the typical polypoid honeycomb lesions and increased caliber. The stomach presented giant rugae producing a cerebriform appearance. The duodenum was involved in continuity with the stomach. The colonic and gastric lesions responded well to radiation and chemotherapy. The clinical picture progressed from lymphosarcoma to a low grade, chronic lymphatic leukemia.

CASE III. A. W., a fifty-six year old female, was first seen on June 9, 1954 with a chief complaint of progressively severe diarrhea, anorexia and lower abdominal pain for one year. She had had a resection of the stomach for lymphosarcoma two and a one half years previously.

Physical examination revealed, as pertinent findings, several bilateral axillary lymph nodes 3 cm. in size and a palpable mass in the left lower quadrant corresponding to the sigmoid.

Proctoscopy disclosed diffuse thickening and a polypoid appearance of the mucosa from about 5 cm. to 22 cm., beyond which point the proctoscope could not be passed.

Total blood protein on admission was 4.6 gm./100 cc.; albumin, 2.6 gm./100 cc. The stools were positive for occult blood. Laboratory data of July 1, 1954 showed: hemoglobin, 9.6 gm; red blood cells, 3.4 million; white blood cells, 10,200; polymorphonuclear leukocytes, 29 per cent; eosinophils, 1 per cent; monocytes, 3 per cent; lymphocytes, 65 per cent; platelets, 238,000.

Biopsy of the rectal lesions and the submitted section of the stomach lesion were interpreted as lymphosarcoma.

On the barium enema roentgenograms dated November 12, 1954 (Fig. 5), the visualized portions of the colon presented irregular polypoid lesions up to 1 cm. in diameter giving a vermiciform appearance. There was thickening of the bowel wall and the contour had an abnormal serrated, wavy margin. These findings were thought to represent ulcerative colitis. A previous barium enema examination on June 23, 1954 gave the same result. Gastrointestinal and small bowel series of June 25, 1954 had demonstrated a well-functioning gastrojejunostomy with a normal gastric stump. While the

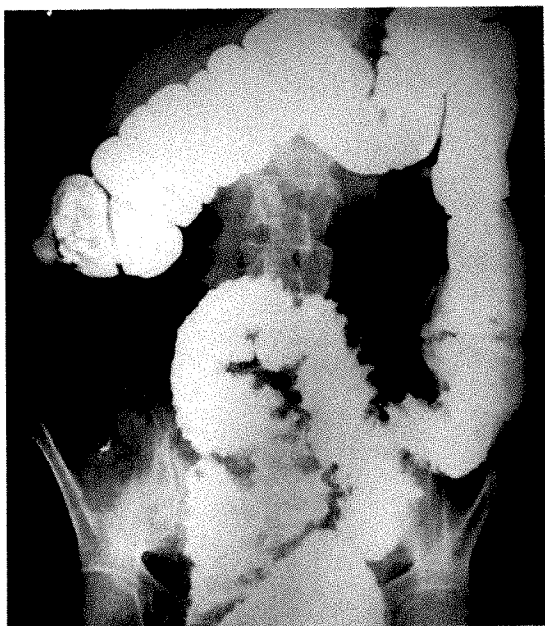


FIG. 5. Case III. November 12, 1954: Diffuse lymphosarcoma of the colon. The colon shows extensive vermiform, polypoid lesions. Note the saw-toothed and wavy margins of the large bowel.

jejunum appeared normal, one loop of ileum presented an abnormal mucosal pattern.

The patient received radiation therapy through single, large, anterior and posterior ports 30×30 cm. directed to the abdomen, 600 r in air to each, and also through one anterior and one posterior pelvic field 10×10 cm., 800 r in air to each. The period of treatment was from July 26 to September 8, 1954. Following completion of therapy, the patient was discharged with complete disappearance of diarrhea and in good clinical condition.

She was asymptomatic until April, 1955 when diarrhea and lower abdominal pain again developed. She was found to have shotty lymphadenopathy in the cervical, supraclavicular, axillary and inguinal regions with hepatosplenomegaly. On June 21, 1955, the hemoglobin was 11.4 gm. and the white blood cell count 39,000, with 88 per cent lymphocytes. The clinical condition deteriorated and she complained of anorexia and weakness. Clinically, a picture of chronic lymphatic leukemia developed. A barium enema examination dated June 13, 1955 demonstrated definite regression of the polypoid lesions (Fig. 6). However, the rectosigmoid still showed an abnormal pattern of the mucosa.

The patient was last seen in July, 1955, when her clinical condition appeared worse. In September, 1955, notification was received that she had expired.

Comment. This is a case of lymphosarcoma, first apparent in the stomach, which subsequently produced generalized colonic involvement. There were diffuse polypoid lesions producing a soap-suds pattern. The bowel wall was thickened and the contour of the colon had an abnormal serrated, wavy margin. These findings closely resembled the ulcerations and pseudopolypoid formations of ulcerative colitis. There was a good response to radiation therapy as evidenced by definite regression of the colonic lesions. The patient later developed the clinical picture of chronic lymphatic leukemia.

CASE IV.* M.Y., a fifty-nine year old female, was admitted on July 19, 1960 with diarrhea and rectal bleeding dating from August, 1959.

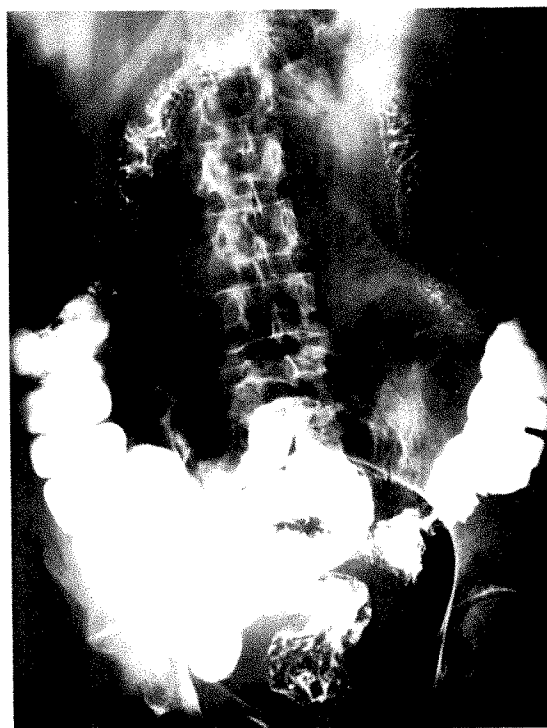


FIG. 6. Case III. June 13, 1955: Almost complete disappearance of the lesions following radiation therapy.

* A patient of Dr. Henry D. Diamond.

A biopsy of a rectal tumor taken at that time, was "consistent with but not diagnostic of lymphosarcoma." She was treated with antispasmodics and muciloids, with some improvement of her symptoms. In December, 1959, abdominal pain and diarrhea again developed. Physical examination revealed the spleen to extend two fingerbreadths below the costal margin. The patient was then started on chlorambucil 2 mg. b.i.d.; this medication was stopped two months prior to admission. She had few abdominal complaints at the time of admission. The only other significant feature of her past history was a left radical mastectomy for carcinoma five years prior to admission.

With the exception of a few small, shotty posterior cervical and inguinal lymph nodes, physical examination on admission was essentially negative. Proctosigmoidoscopy showed unusual ill-defined, convoluted, nonobstructing, ridge-like, polypoid lesions covered by intact mucosa in the rectum and sigmoid.

Biopsies of the rectal lesions were reported

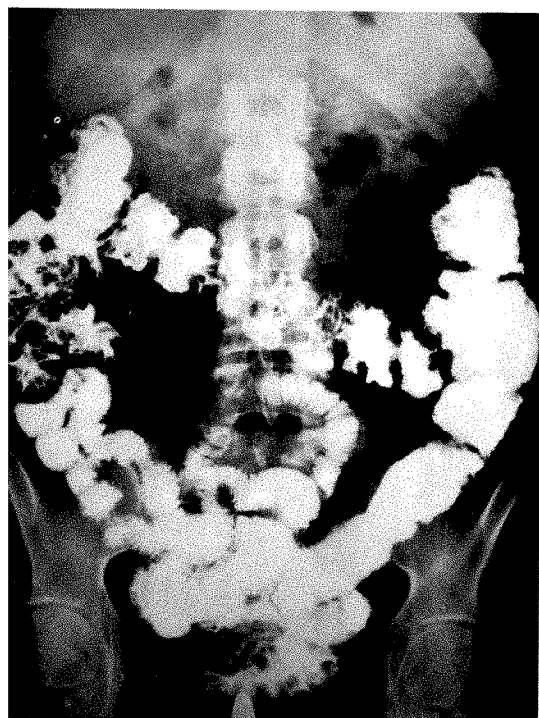


FIG. 7. Case IV. *January 25, 1960*: Diffuse lymphosarcoma of the colon. Irregular polypoid lesions are seen throughout. Note the increased caliber and the cerebriform, soap-suds appearance of the rectosigmoid and ascending colon.

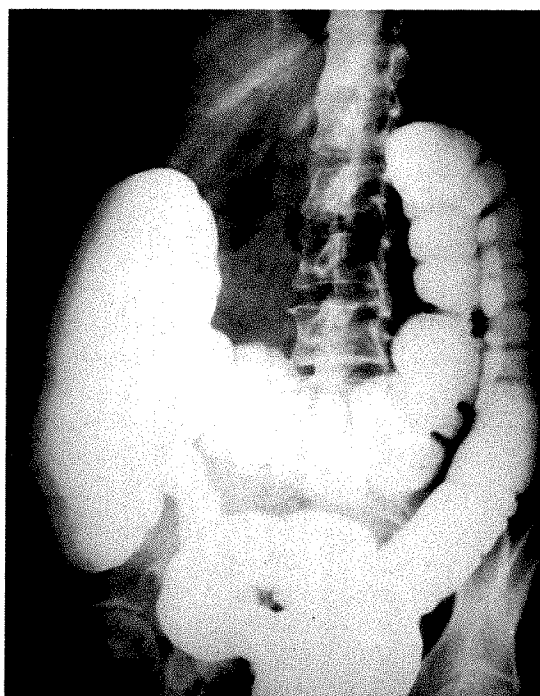


FIG. 8. Case IV. *July 22, 1960*: Normal appearance of the colon following chemotherapy.

as diffuse infiltration of the mucosa and submucosa by lymphosarcoma of the lymphocytic type.

The stool was positive for occult blood. The white blood cell count was 5,700 and the hemoglobin was 11.6 gm.

Submitted barium enema studies dated September 22, 1959 and January 25, 1960 (Fig. 7) demonstrated extensive and diffuse polypoid filling defects, 0.5 to 1.5 cm. in diameter, throughout the entire colon. These lesions were not well circumscribed, but appeared to be continuous with each other, and produced a soap-suds, cerebriform, mucosal pattern. The colon was increased in caliber and had a wavy, serrated contour somewhat resembling minute ulcerations. These were most prominent in the rectosigmoid region. There was lack of contractility of the bowel following evacuation but some distention seemed to occur with air insufflation.

Following chemotherapy, a barium enema study of July 22, 1960 (Fig. 8) revealed complete regression of the lesions in the large bowel. Upper gastrointestinal and small bowel series of July 26, 1960 were normal. During this stay in the hospital, the patient had an episode of

bloody diarrhea which subsided within a few days. She was discharged on July 30, 1960 to the care of her local physician.

Comment. This is an example of diffuse lymphosarcomatous involvement of the entire colon. The stomach and the small bowel were free of disease. The colon harbored the typical confluent polypoid lesions producing a vermiform or soap-suds appearance. The wall of the bowel had a wavy, serrated contour somewhat resembling minute ulcerations. There was a dramatic regression of the colonic lesions with chemotherapy, although residual disease was still discernible at sigmoidoscopy.

CASE V.* D.Y., a forty-five year old male, was first seen on October 13, 1939 with a history of a left submandibular mass for three and one half years. Three months prior to his hospital visit he became aware of another mass on the left side of his neck, easy fatigability and an occasional sensation of breathlessness.

Pertinent findings at physical examination were a 7 cm. mass on the left side of the neck, a 3.5 cm. mass in the left submandibular region, and two 1.5 cm. masses on the right side of the neck. Aspiration biopsy of a submental lymph node on January 14, 1939 had been reported as consistent with lymphosarcoma.

On October 16, 1939 the following values were determined: hemoglobin, 7.5 gm.; red blood cells, 3.8 million; white blood cells, 7,800; segmented, 71 per cent; monocytes, 3 per cent; lymphocytes, 26 per cent.

Radiation therapy was given to the neck with good response and he remained well until September, 1941 when left inguinal lymphadenopathy developed which was treated by radiation therapy. In March, 1942, he noted right femoral and inguinal lymphadenopathy and in July, 1943 he presented with enlarged left axillary lymph nodes which were also treated with external irradiation with good results.

The patient had several episodes of abdominal pain, diarrhea, and melena in August and September, 1942, and in March and September, 1943. A barium enema study performed on September 8, 1943 (Fig. 9A) showed innumerable, irregular polypoid lesions, 0.5 to 3 cm. in size, throughout the visualized portions of

colon. These spherical defects were continuous with each other, forming a soap-suds or cerebriform appearance. The colon was increased in caliber and there was a wavy, serrated contour, particularly in the rectum and sigmoid. An upper gastrointestinal series dated September 10, 1943 showed abnormally coarse rugae in the gastric cardia and antrum, and in the duodenum. This was interpreted as consistent with lymphosarcoma. Gastroscopy on September 2, 1943 was thought to demonstrate diffuse invasion of the stomach by lymphosarcoma. Proctoscopy on September 21, 1943 revealed a pale edematous mucous membrane with a diffuse, sessile, polypoid enlargement. Biopsy of the rectal mucosa showed lymphosarcoma. The white blood cell count was 7,000 at this time.

From February 24 to March 10, 1944, the patient received 500 r in air to an anterior abdominal port 25×19 cm. and to a lumbar port 25×20 cm. with 250 kv. roentgen therapy. From May 1 to May 12, 1944, 900 r in air was given via anterior and posterior ports, 11×13 cm. each, to the left lower abdominal region.

A barium enema study on September 1, 1944 (Fig. 9B) demonstrated marked improvement in the appearance of the colon as compared with the study of September 8, 1943, due to regression of the polypoid lesions. Although the right side of the colon was not completely filled, an abnormal mucosal pattern was still noticeable at the hepatic flexure.

From June, 1944 to February, 1947, the patient was seen frequently in the clinic and received radiation therapy to many regions of the body which were involved by lymphosarcoma, including the axillary, inguinal epitrochlear, preauricular, mediastinal, and cervical lymph nodes, and the conjunctiva and hard palate. The lesions usually regressed rapidly with small doses of external irradiation, but tended to recur later.

In February, 1946, 5 doses of 1.3 mc each of P^{32} were given and in October, 1946, 6 injections of 6 mg. each of nitrogen mustard were administered.

At the end of 1946, the general status of the patient, which previously had been relatively good, began slowly to deteriorate. The white blood cell count dropped to 1,100 in February, 1947, and persistent anemia developed despite numerous blood transfusions.

On May 24, 1947 the patient expired in another hospital with lobar pneumonia.

* A patient of Dr. Lloyd F. Craver.

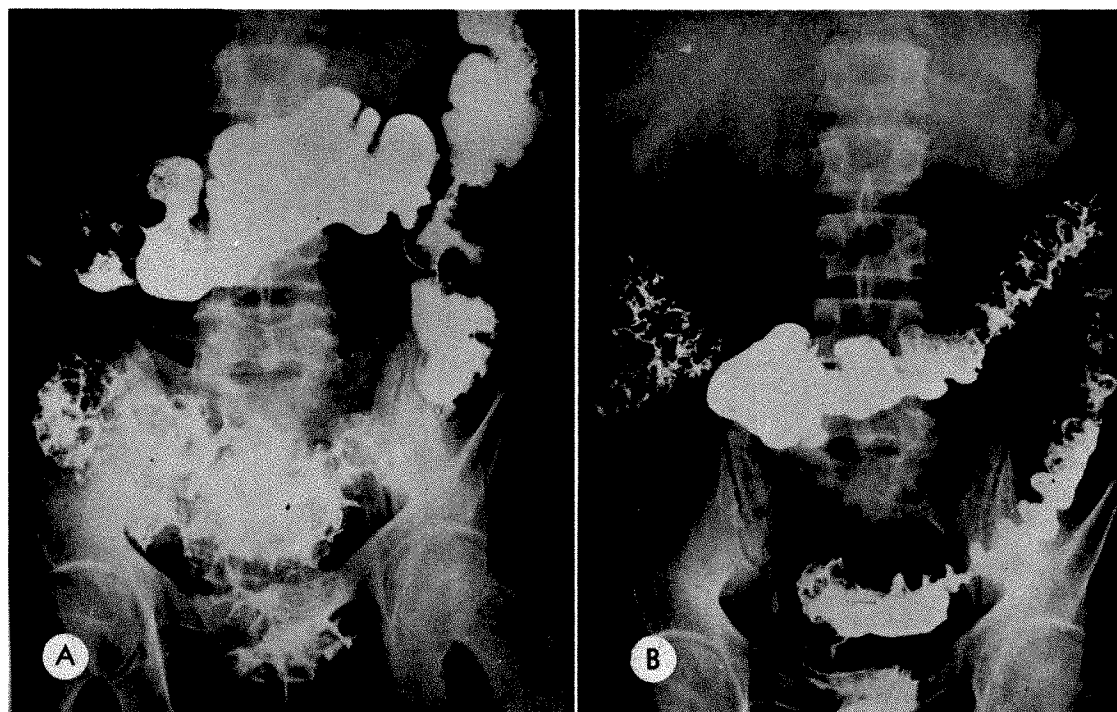


FIG. 9. Case v. (A) September 8, 1943: Diffuse lymphosarcoma of the colon. Note the soap-suds and cerebriform appearance of the polypoid lesions of the colon, as well as the increased caliber and serrated contour. (B) September 1, 1944: Regression of the colonic lesions after radiation therapy to the abdomen.

Comment. This is another example of diffuse lymphosarcoma of the large bowel with the typical soap-suds or cerebriform appearance of the entire colon, which also presented a wavy, serrated contour. There was involvement of the stomach and duodenum as well. The colonic lesions regressed significantly after radiation therapy to the abdomen.

CASE VI. J.P., a sixty-four year old male, was first seen on January 3, 1958 with a history of rectal bleeding, diarrhea of 6 to 8 watery stools per day, weakness, and inguinal lymphadenopathy for one year.

Physical examination revealed a generalized lymphadenopathy with the largest lymph node in the left axilla measuring $3 \times 3 \times 1$ cm. The liver was palpated 2 cm. and the spleen 5 cm. below the costal margins.

Laboratory results of October 23, 1958 were: hemoglobin, 9.3 gm.; platelets, 136,200; white blood cell count, 217,000 with 94 per cent lymphocytes.

Proctosigmoidoscopy on October 17, 1958, revealed the mucosa to be pale and friable with

multiple, granular, whitish excrescences 1 to 2 mm. in size and multiple petechial hemorrhages. Gross blood and clots were also observed.

Submitted barium enema studies of May 10, 1958 revealed diverticulosis throughout the colon but no other obvious organic lesions. However, a barium enema examination on October 20, 1958 showed multiple, irregular outpouchings of barium, 0.1 to 0.3 cm. in size, throughout the sigmoid and descending colon which had not been present on the study of May 10, and which were interpreted as multiple ulcerations. The remainder of the colon appeared normal.

From October 25 to December 16, 1958, the patient received daily doses of chlorambucil which varied from 2 to 12 mg., with an average dose of 8 mg. daily.

A significant improvement in the clinical status was noted early in December, 1958. The diarrhea decreased and the general condition was better. Proctoscopy up to 25 cm. on December 12, 1958 revealed no definite areas of ulceration, although the rectal mucosa was friable and covered with multiple small gray patchy areas. The white blood cell count by

December 14, 1958 had dropped to 21,200. The hemoglobin was 9.3 gm. and the platelets 210,500. Physical examination disclosed no significant lymphadenopathy except for slightly enlarged lymph nodes in the left axilla and both inguinal regions. The hepatosplenomegaly was unchanged.

In April, 1959, the diarrhea became worse and the patient noted rectal bleeding. Proctosigmoidoscopy performed on April 24, 1958 disclosed superficial ulcerations in the rectum which bled easily. The visualized mucosa had a granular appearance, was friable, and was covered in several areas by a thin whitish membrane. The appearance resembled that of ulcerative colitis.

Bone marrow smear on May 1, 1958 showed over 90 per cent lymphocytes interpreted as characteristic of chronic lymphatic leukemia.

Barium enema study of May 5, 1959 (Fig. 10) showed, as the most prominent feature, innumerable, irregular outpouchings, 0.2 to 0.5 cm. in size and filled with barium, projecting along the surface of the colon; these were interpreted as ulcerations and were distributed throughout the entire large bowel. They had increased in size and number since the study on

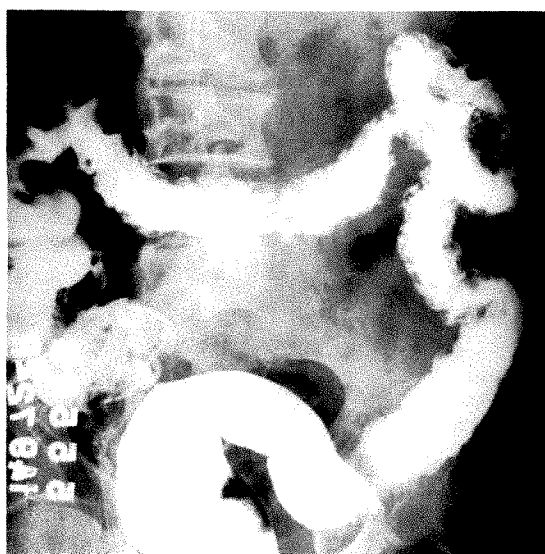


FIG. 10. Case VI. May 5, 1959: Chronic lymphatic leukemia with diffuse involvement of the large bowel. Innumerable irregular outpouchings which project along the surface of the colon are filled with barium and were interpreted as ulcerations. Note also the discrete, diffuse polypoid lesions throughout the bowel.

October 20, 1958. Multiple, polypoid filling defects, 0.5 to 1 cm. in size, were also noted throughout the colon. The hepatosplenomegaly persisted. A gastrointestinal and small bowel series of May 8, 1959 was reported as normal. Numerous samples of stool taken in May, 1959 showed no evidence of protozoa or parasites. The white blood cell count was 117,000.

On May 14, 1959, following cleansing enemas, the patient developed the clinical picture of an acute abdomen; this led to an emergency exploratory laparotomy. At operation, the entire colon was found to be studded with areas of hypertrophied lymphoid tissue, and an intramesenteric perforation of the sigmoid was found. A transverse colostomy was performed.

A biopsy on June 26, 1959, of proliferating mucosa at the colostomy site revealed pseudoepitheliomatous hyperplasia of squamous epithelium and underlying lymphocytic infiltration consistent with leukemia.

During the year June, 1959 to June, 1960, the patient was seen at frequent intervals. His clinical status remained approximately the same with continuous episodes of diarrhea which were more or less controlled with antispasmodics and barbiturates.

Sigmoidoscopy on June 29, 1960 showed diffuse thickening of the mucosa and multiple soft polypoid excrescences. The appearance was not characteristic of ulcerative colitis or true polyposis. A biopsy of a lesion 5 mm. in diameter and 10 cm. from the anal verge was reported as granulation tissue with ulceration and leukemic infiltration. Therapy with chlorambucil was restarted on June 28, 1960. The initial dose of 14 mg. daily was subsequently decreased to 4 mg. by September 1, 1960. The white blood cell count on June 20, 1960 was 166,000 but on September 22, 1960 it had dropped to 8,500 and at this time the patient was relatively asymptomatic with only occasional bouts of diarrhea.

A barium enema study of September 26, 1960 (Fig. 11) showed disappearance of the innumerable outpouchings of barium along the colonic wall which had been present on the roentgenogram of May 5, 1959. However, multiple polypoid lesions were still seen throughout the colon, especially in the proximal sigmoid and ascending portions. A short narrowed segment was also noted in the midtransverse colon at the site of the previous colostomy.

The patient is being followed in the clinic at the present time.

Comment. This is a patient with chronic lymphatic leukemia and diffuse involvement of the large bowel. The small bowel and upper gastrointestinal tract were not affected. The most important feature was the presence of innumerable outpouchings of barium along the margins of the colon interpreted as ulcerations. The typical polypoid lesions were also present as well. Considerable regression of the colon lesions followed treatment with chlorambucil.

DISCUSSION

Experience with the 6 cases reported above combined with a review of their gross pathology and roentgen findings permits one to state that diffuse involvement of the colon by malignant lymphoma has a fairly typical roentgen appearance. This is characterized by innumerable, diffuse, polypoid lesions throughout the entire colon, varying in size from a few millimeters to 2 or 3 cm. or more. They appear as elevations in bas-relief and are not pedunculated in the great majority of instances. The polypoid lesions are either rounded or vermiform and, being continuous with each other, present a cerebriform appearance. There may be honey-combed loculations with a frothy, soap-suds-like appearance. The bowel wall is thickened and has an irregular, shaggy contour with multiple, saw-toothed, wavy, serrated projections which resemble ulcerations. The caliber of the colon is often enlarged and there is failure of collapse and apposition of its walls following evacuation. This is probably due to the somewhat rigid thickened and redundant mucosa and submucosa. Segments of narrowing or obstruction are not usually encountered. The colon distends after insufflation and, with distention, the polypoid lesions have a tendency to become somewhat less prominent.

There is associated involvement of either the stomach or small bowel in more than

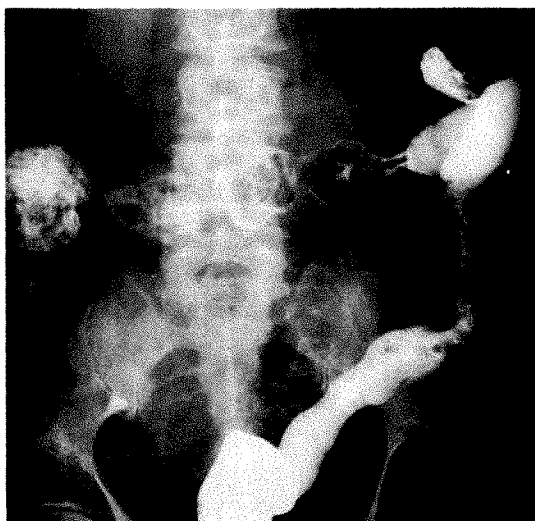


FIG. 11. Case VI. September 26, 1960: Disappearance of the abnormal contour of the colon following treatment with chlorambucil; however, the multiple polypoid lesions are still seen.

three fourths of the cases. The stomach presents with diffuse hypertrophy of the mucosal folds producing a typical cerebriform appearance, with or without involvement of the duodenum. The small bowel shows evidence of diffuse multiple polypoid lesions. Both the stomach and the small bowel are involved in over half of the cases.

Following either radiation therapy or chemotherapy, or both, the polypoid lesions usually regress or disappear completely but tend to recur.

Although it has been said that diffuse lymphomatous disease of the alimentary tract is not followed by leukemia,¹⁷ 2 of these cases developed the clinical and hematologic picture of chronic leukemia.

DIFFERENTIAL DIAGNOSIS

Notwithstanding the very characteristic roentgen findings the following conditions may have to be considered in the differential diagnosis.

In familial polyposis, the colon usually shows multiple, well-circumscribed, round, polypoid lesions, sometimes with long pedicles.^{29,30} Associated diffuse involvement of the small bowel and stomach is

rare in familial polyposis, although a few such cases have been documented in the literature.^{23,34} As mentioned above, more than three fourths of the cases of diffuse lymphoma of the colon show simultaneous involvement of either the small bowel or stomach. A biopsy should always be done in the doubtful cases because familial polyposis is a surgical problem, whereas in diffuse lymphomatous disease of the colon, the treatment of choice is radiation therapy or chemotherapy.

The Peutz-Jeghers syndrome, in which the small bowel, particularly the jejunum, shows multiple adenomatous polyps, may also be associated with multiple polyps of the colon and stomach. However, the diagnosis is made clinically by the distinctive type of melanin pigmentation of the oral mucosa, lips and digits.²⁵

Pseudopolypoid changes and a shaggy abnormal contour of the colon in ulcerative colitis may make this disease difficult to differentiate from diffuse lymphomatous invasion of the colon. However, the typical collar button ulcerations, the shortening of the colon, loss of haustrations, the stiff, tubular appearance and segments of narrowing or stricture often seen in ulcerative colitis, especially in its late stages, are absent.

Amebic colitis may also involve the entire colon producing a shaggy, saw-toothed contour of the bowel wall. In an advanced stage, it may resemble chronic nonspecific ulcerative colitis.^{16,40} It usually presents a typical cone-like deformity of the cecum or multiple segments of stenosis or constriction of the colon.^{15,18,40,47} The latter two findings are not observed in diffuse lymphomatous disease of the colon. The diagnosis is confirmed by the presence of vegetative or cystic forms of *Endamoeba histolytica* in the stools and by the repair of the colonic lesions following antiamebic therapy.⁴

Granulomatous ileocolitis also often shows an irregular narrowing deformity and shortening of the involved bowel but

these are not present in diffuse lymphomatous invasion of the colon.

Menetrier's disease, Gordon's enteropathy and other protein losing gastroenteropathies should be differentiated by means of biopsy, electrophoretic studies of serum and intestinal contents, and I¹³¹ labelled polyvinyl pyrrolidine excretion tests.²⁸ They may present a roentgen appearance somewhat similar to that of diffuse lymphomatous diseases of the gastrointestinal tract.

Benign lymphoid polyps of the rectum, according to Helwig and Hansen,²¹ have a fairly typical histologic appearance and very rarely occur in locations other than the lower rectum or anus.

SUMMARY

1. Six cases of diffuse lymphomatous involvement of the colon are presented.
2. The gross pathologic and roentgenologic appearances found in cases reported in the literature are reviewed and summarized.
3. A description of the characteristic roentgenographic appearance in this form of colonic disease is given with diagnostic criteria for the recognition of this type of abnormality.
4. The frequently associated involvement of the stomach and small bowel is pointed out.
5. Differential diagnostic points are enumerated.
6. Although the rarity of diffuse lymphomatous disease of the colon is affirmed, its recognition is of prime concern to the radiologist and clinician, since a correct diagnosis is necessary for proper management.

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PREPARATION OF THE COLON FOR BARIUM ENEMA STUDY*

A COMPARATIVE EVALUATION OF THREE TECHNIQUES

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THE barium enema examination continues to be the best diagnostic technique available for the routine evaluation of the status of that portion of the colon above the reach of the sigmoidoscope. If an accurate evaluation is to be made, it is essential that the colon be thoroughly cleansed of its luminal contents prior to the performance of the examination. That this is all too often not achieved is frustratingly clear to most radiologists, who are frequently forced to qualify radiologic reports by stating that while no gross lesions are demonstrated, residual feces, fluid or air prevent ideal evaluation. It is also apparent that in a busy hospital radiology department it is necessary to rely for the most part on routine preparation methods and techniques.

In recent years a variety of commercial products relating to colon cleansing have appeared on the market, and their use in the preparation of the colon for barium enema examinations has been recommended. It is proposed at this time to present a study evaluating the efficacy of two of these products as compared with a standard preparation procedure. In addition, the patients' subjective reactions to the preparation are also evaluated.

METHOD OF STUDY

Three hundred essentially consecutive routine barium enema examinations performed on in-patients at the University of Mississippi Medical Center comprise the material used in the present study. Air contrast or other nonroutine techniques were not included. The great majority of the examinations were performed on adults, with wide variation in the clinical indications

for the procedure as would be expected in a general hospital population.

In all instances a standard barium (Veri-O-Pake) and water preparation was employed as the contrast material. The roentgenologic portion of the examination consisted of fluoroscopic observation of the colon as it filled plus a variable number of spot roentgenograms. Postfluoroscopy, routine posteroanterior and right and left anterior oblique roentgenograms of the filled colon were obtained, as well as a postevacuation anteroposterior roentgenogram of the abdomen.

Certain features were common to the patient preparation in all 300 examinations. These included a light supper the evening before the examination, followed by fluids only until bedtime, and on the morning of the examination only small amounts of water were allowed per os.

The 300 examinations were divided into three equal groups, varying as to the laxative-enema combination used during the preparation of the patient. The preparation technique in these three groups was as follows.

Group I—Castor Oil and Tap Water Enema. Early in the evening prior to the day of examination castor oil (2 fl. oz.) was taken per os. On the morning of the examination, a tap water enema (1 qt.) was administered by ward personnel, with instructions to repeat if not effectual.

Group II—Castor Oil and Fleet Enema Disposable Unit. Early in the evening prior to the day of examination castor oil (2 fl. oz.) was taken per os. On the morning of the examination, an enema was administered by ward personnel, using a single

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Fleet enema disposable unit ($4\frac{1}{2}$ fl. oz.).

Group III—Phospho-Soda (Fleet) and Fleet Enema Disposable Unit. Early in the evening prior to the day of examination Fleet phospho-soda ($1\frac{1}{2}$ fl. oz.) was taken per os. On the morning of the examination an enema was administered by ward personnel, using a single Fleet enema disposable unit ($4\frac{1}{2}$ fl. oz.).

At the time of the barium enema examination, each patient was questioned by the radiologist performing the procedure, who checked not only the type of preparation but also the patient's subjective response to it. The incidence of nausea, vomiting and abdominal cramps, as well as the number of bowel movements occurring during the preparation period, was recorded in each instance.

At the completion of the 300 examinations, the roentgenograms comprising each examination were placed in separate film envelopes. The authors then jointly reviewed each set of roentgenograms, without reference at this time to the type of preparation used. In each instance, on the basis of the roentgenologic appearance, an estimate was made as to the quantity of residual feces and gas in the colon. In addition, each examination was classified as to the authors' estimate of the over-all quality of the colon cleansing and the adequacy of the study. After all 300 studies had been reviewed and classified, the results were tabulated against the type of colon preparation used. The castor oil-tap water enema technique (Group I) was used as the standard by which the other two methods were compared. The patients' subjective reactions were similarly tabulated.

FINDINGS

The roentgenologic evaluation as to the quantity of residual feces in the colon at the time of the performance of the barium enema studies is summarized in Table I. The figures are shown as percentages, but since there were 100 examinations in each of the three preparation groups, they also indicate the actual number of studies done.

TABLE I
QUANTITY OF RESIDUAL FECES IN COLON

Quantity of Feces	Castor Oil and Water Enema	Castor Oil and Fleet Enema	Phospho-Soda and Fleet Enema	Average
	(per cent)	(per cent)	(per cent)	(per cent)
None	13	16	9	13
Minimal	57	50	47	51
	70	66	56	64
Moderate	21	27	32	27
Marked	9	7	12	9
	30	34	44	36

It will be noted that ideal cleansing, as evidenced by no demonstrable feces, was found in only 13 per cent of the 300 studies. In 51 per cent of the examinations, the amount of residual feces was estimated as being minimal, while in the remaining 36 per cent it was recorded as being moderate to marked. As regards the three techniques of preparation, it is not felt that there was any marked difference in their ability to empty the colon of fecal material, although over-all the castor oil-water enema studies did appear to show the least residual fecal material, and the phospho-soda-Fleet enema group the most.

The findings regarding the amount of residual gas in the colon at the time the barium enema examination was undertaken are summarized in Table II.

In 11 per cent of the 300 examinations, there was no evidence of residual gas in the colon on the barium enema roentgenograms. In 64 per cent, the presence of minimal amounts of gas was recorded, and in 25 per cent there were felt to be moderate to marked quantities of gas present.

Initially, it was postulated that the ward personnel might be introducing variable amounts of air into the colon during the administration of tap water enemas, and that, if this were true, the Fleet enema disposable unit preparation would result in less gas

being present. We were not, however, able to prove this, since less residual gas was found in the castor oil-water enema group.

In addition to recording the relative quantities of residual feces and gas in the colon, each study was also classified as to over-all quality. This took into account not only the quantities of residual feces and gas, but also such factors as the relative proportions of these elements and their distribution along the course of the colon. It proved impossible to completely eliminate such factors as excessive filling of the ileum with contrast material, marked redundancy of the colon or poor evacuation in making this evaluation. These findings are summarized in Table III.

In only 7 per cent of the 300 examinations was the over-all colon preparation and visualization considered to be excellent. In 14 per cent cleansing and visualization were so inadequate that it was necessary to call the study grossly unsatisfactory and to request that it be repeated. In 79 per cent of the studies, the over-all evaluation was recorded as being passable. This term "passable" requires further definition. From the authors' stand-point, it implies that the degree of colon cleansing and visualization was such that in the practicalities of everyday radiology a diagnostic interpretation of the status of the colon could be made,

TABLE II
QUANTITY OF RESIDUAL GAS IN COLON

Quantity of Gas	Castor Oil and Water Enema	Castor Oil and Fleet Enema	Phospho-Soda and Fleet Enema	Average
	(per cent)	(per cent)	(per cent)	(per cent)
None	14	11	8	11
Minimal	66	65	61	64
	—	—	—	—
	80	76	69	75
Moderate	18	19	25	21
Marked	2	5	6	4
	—	—	—	—
	20	24	31	25

TABLE III
OVER-ALL QUALITY OF EXAMINATION

Roentgenologic Evaluation	Castor Oil and Water Enema	Castor Oil and Fleet Enema	Phospho-Soda and Fleet Enema	Average
	(per cent)	(per cent)	(per cent)	(per cent)
Excellent	6	5	11	7
Passable	80	78	79	79
Unsatisfactory	14	17	10	14

without requesting that the examination be repeated. It does not imply that the studies were always truly satisfactory, since in many instances it was necessary to qualify the radiologic report as to the degree of colonic evaluation that was feasible. The type of preparation used did not appear to influence the over-all evaluation pattern.

The patients' subjective reactions to the type of colon preparation used, the incidence of nausea, vomiting and abdominal pain or cramps are summarized in Table IV.

For the purposes of this study it was assumed that any nausea, vomiting or abdominal discomfort occurring during the colon preparation procedure was due to the preparation, although it is probable that patient disease was responsible for these symptoms in some instances. Thirty-five per cent of the total number of patients

TABLE IV
SUBJECTIVE REACTION TO TYPE OF COLON PREPARATION

Type of Reaction	Castor Oil and Water Enema	Castor Oil and Fleet Enema	Phospho-Soda and Fleet Enema	Average
	(per cent)	(per cent)	(per cent)	(per cent)
Nausea	42	33	30	35
Vomiting	13	10	10	11
Cramps or Abdominal Pain	46	36	29	37

stated that they had observed nausea during the preparation period, and 11 per cent had vomited. In 37 per cent abdominal discomfort was noted, this usually being cramp-like in nature. The phospho-soda plus Fleet enema preparation technique apparently produced over-all somewhat fewer subjective symptoms than did the castor oil plus tap water enema preparation, but this is probably not of real significance.

Many of the patients were unable to quantitate accurately the number of bowel movements associated with the colon preparation procedure. Approximately 11 per cent of the patients stated that the preparation had produced only one bowel movement. In 41 per cent the number of movements was estimated to vary from two to four, while 48 per cent of the patients stated that they had had five or more movements. The type of preparation used did not appear to influence the pattern or number of bowel movements.

DISCUSSION

There is no preparation technique which will result in completely satisfactory cleansing of the colon in every instance. It is also obvious that there has to be some compromise between the elaborate preparation methods which have been recommended in the literature and the practicalities of everyday radiology and medical practice.

Most authors agree that the volume of fecal material in the colon can be reduced by fasting or restricting solid food intake; however, many physicians are reluctant to recommend that their patients remain routinely on a clear liquid diet for a period of twenty-four to seventy-two hours prior to the performance of a barium enema examination, as has been suggested.⁵

It is the general consensus of opinion that a vigorous cathartic should be given twelve to twenty-four hours prior to examination, and castor oil continues to be the most commonly used substance for this purpose.³ As indicated by the present study, there is considerable individual variation in its effectiveness, as judged by

the number of bowel movements produced and the degree of colon cleansing. This same individual variation in all probability applies to any of the usual laxatives.

Opinions regarding the value of enemas in colon preparation also vary considerably. Some authors have relied heavily on multiple enemas² while, at the other extreme, it has been suggested that enemas do more harm than good and should therefore be eliminated as part of the colon preparation.³ It is difficult to escape the conclusion, however, that a properly administered enema can effectively eliminate large quantities of luminal contents from the colon. It would also appear reasonable to anticipate that one or two tap water or soapsuds enemas, properly administered, would be more effective in cleansing the right half of the colon than would the smaller quantity of liquid introduced by the Fleet enema disposable unit. In the present study the findings tend to support this assumption. It may well be, however, that an enema with a Fleet disposable unit is frequently just as effective as the average tap water enema administered casually by ward personnel, since it is suspected that there is a considerably greater chance for a tap water enema to be improperly administered than would be the case in the disposable unit type enema. It should also be pointed out that the disposable enema unit results in considerable time saving for busy ward personnel, so that in the long run these commercial units may be as economical as a tap water enema.^{4,6}

The routine colon preparation technique for barium enema studies used at the University of Mississippi Medical Center combines castor oil and tap water enemas, as outlined in the Group I series in the present study. It is not suggested that this particular preparation method is ideal, but it is suspected that it comes close to the average preparation procedure being used in this country. This preparation method was therefore used as the baseline by which the techniques described for Groups II and III were evaluated. The quantitative re-

sults of the amounts of residual feces and gas would suggest that the latter two techniques were not as effective as the castor oil-water enema preparation, but on the over-all roentgenologic evaluation no significant difference could be detected.

In our experience it is apparent that the average barium enema study is a rather gross screening procedure with any of the three preparation procedures employed, and that the quality of the usual preparation and examination is such that small organic lesions could well pass undetected.¹ It is suspected that the radiologist is more aware of the diagnostic limitations of the routine barium enema study than is the average clinician requesting such studies.

An evaluation study of the type presented has certain inherent limitations which should be mentioned. There is no objective way to quantitate the degree of colon cleansing, and the terms "minimal," "moderate" or "marked" depend upon subjective evaluation. Also, other viewers might not have the same ideas as to what constitutes an excellent, passable or unsatisfactory study. Limitations of this nature should result in the acceptance of the numerical data presented as being relative rather than absolute.

SUMMARY

A study has been presented dealing with the efficacy of colon preparation in 300 barium enema examinations, as evaluated roentgenologically, along with the patients' subjective reactions to the procedures. Three different preparation techniques were utilized, differing as to the type of laxative and enema employed. As judged by the findings on roentgenograms, there was no significant difference between these three techniques as regards the over-all quality or adequacy of the examinations, although those colons prepared with a standard castor oil-water enema routine appeared to be more adequately cleansed.

In 64 per cent of the examinations, minimal or no residual feces were detected within the colon, with the remaining 36 per cent showing moderate to marked amounts of residual feces. In 75 per cent of the studies, minimal or no residual gas was noted within the colon, 25 per cent demonstrating moderate to marked amounts of gas.

An over-all evaluation as to the quality of the preparation and the roentgenograms revealed that the studies were excellent in 7 per cent of the total group, passable in 79 per cent and grossly unsatisfactory in the remaining 14 per cent. Many of those in the passable group were not truly satisfactory studies, since it was frequently necessary to qualify the degree of colon evaluation that was feasible.

Thirty-five per cent of the 300 patients observed nausea during the preparation procedure, and 11 per cent vomited. Cramps or abdominal pain were observed in 37 per cent of the group. There was considerable variation in the number of bowel movements associated with any given preparation technique.

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PREPARATION OF THE COLON FOR BARIUM ENEMA EXAMINATION

A COMPARISON OF THREE AGENTS

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THE satisfactory preparation of the colon preceding barium enema examination has long been a perplexing problem to radiologists. The purpose of this study is to evaluate two relatively new agents, comparing them with the most widely accepted method which is the oral administration of castor oil followed by cleansing enemas.^{1,2,7}

METHOD OF INVESTIGATION

The roentgenograms of 295 barium enema examinations performed between December, 1957 and August, 1959 were reviewed by the author without knowledge of the method of preparation. During this period, three methods of preparation had been used. Group 1: 79 patients; two ounces of castor oil were administered orally at 4 P.M. on the afternoon preceding the examination. Cleansing enemas were given early on the morning of the examination. Group 2: 95 patients; these patients were given 30 mg. of bisacodyl (dulcolax) orally at 4 P.M. on the afternoon preceding the examination. Two 10 mg. rectal suppositories containing the same material were inserted early on the morning of the examination. Group 3: 121 patients; these patients were given a single $\frac{3}{4}$ ounce canister of X-prep powder in a glass full of milk or water at 4 P.M. on the afternoon preceding the examination. No additional preparation was carried out in this group.

The fact that all patients in the above groups were prepared precisely as prescribed has been documented either by the nurses notes on hospital records or by specific statement of the patient. This series does not include any patients in whom the

preparation deviated from one of the above regimens. Both in-patients and out-patients are included.

The patients in Groups 2 and 3 were questioned concerning side effects such as cramping, nausea and vomiting, etc. The patients in Group 3 (X-prep) were questioned concerning palatability. The patients in Group 1 (castor oil) were not questioned since this portion of the study was carried out in retrospect.

The roentgenograms were interpreted as belonging to one of three categories as follows: (1) excellent—no residual fecal material identified; (2) acceptable—fecal material in the cecum and/or a single small collection of fecal material elsewhere in the colon; (3) unsatisfactory.

RESULTS

The results are tabulated in Table 1. The percentage of unsatisfactory results is slightly lower in Groups 2 and 3 (dulcolax and X-prep). The percentage of abdominal cramping was 69 per cent for both of these groups. Seventeen per cent of the dulcolax patients became nauseated as compared with 11 per cent of the X-prep group. In no instance was the cramping or nausea considered severe. Vomiting occurred infrequently. Nineteen per cent of the X-prep group considered the material to have an unpleasant taste.

DISCUSSION

The use of bisacodyl as a colon evacuant was described in the European literature as early as 1914.⁵ The drug acts by direct contact with the colonic mucosa after either oral or rectal administration by inducing

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The contents of this article reflect the author's personal views and should not be construed as a statement of official Air Force policy.

TABLE I
RESULTS OF COLON PREPARATION STUDY

Agent	No. Patients	Adequacy of Preparation (Categorized*)			Nausea	Vomiting	Cramping
		(1)	(2)	(3)			
Castor Oil 2 oz. + enema	79	20 (25%)	24 (31%)	35 (44%)	—	—	—
Dulcolax, 30 mg. plus two 10 mg. suppositories	95	33 (35%)	30 (31%)	32 (34%)	17 (17%)	1 (1%)	70 (69%)†
X-Prep	121	38 (29%)	48 (36%)	47 (35%)	14 (11%)	3 (2%)	92 (69%)†

* (1) No residual fecal material identified.

(2) Fecal material in cecum and/or single small collection of fecal material elsewhere in colon.

(3) Unsatisfactory.

† Mild only.

peristaltic movements. The toxicity is low.^{5,9} The rectal suppositories are effective within fifteen to sixty minutes.⁵

The use of bisacodyl has not been widely reported in the North American literature. Where its use has been reported, it has been considered a satisfactory preparation for barium enema examination.^{4,6,8} However, the criteria to be met for "satisfactory" results have not been clearly stated. It is therefore difficult to compare results.

X-prep is a cocoa-flavored powder containing the standardized active constituent of cassia acutifolia pod (senna). It is absorbed in the small bowel and the active ingredient reaches the colon through the blood stream. In the colon, the senna glycosides react with enzymes from *B. coli* to produce new compounds which, in turn, cause contraction of the large bowel by their stimulating effect of the neuromuscular apparatus.¹⁰

Statman¹¹ reports "excellent" results in 92 per cent of 103 cases with no "unsatisfactory" results. The criteria for "excellent," "good," and "unsatisfactory" are not stated. Nineteen per cent of his patients complained of cramping. The satisfactory results following the use of the material have also been reported by Kaufman.³

This study, as well as similar ones by others, have established that bisacodyl

(dulcolax) and X-prep (senna) are satisfactory materials for cleansing of the colon preparatory to barium enema examination. The present study indicates that they may be slightly better than the castor oil and enema method. They are certainly more acceptable to the patient. Another important factor is that enemas need not be given with either of the newer media—constituting a great convenience to the patient and the hospital alike.

SUMMARY

The satisfactory preparation of the colon preceding a barium enema examination has been and is a perplexing problem to radiologists. The purpose of this study was to evaluate 2 new agents, comparing them with the most widely accepted method, which is castor oil followed by cleansing enemas.

Two hundred and ninety-five examinations were included in the study. Ninety-five patients were prepared with the contact laxative, bisacodyl (dulcolax); 121 patients were prepared with a preparation containing senna (X-prep); and 79 patients were prepared with 2 ounces of castor oil followed by cleansing enemas. All of the examinations were reviewed and evaluated by the author and without knowledge of the preparation used.

Dulcolax and X-prep proved to be as adequate as castor oil and enemas in evacuating the colon under the conditions of this study.

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We wish to thank the Gray Pharmaceutical Company, Inc., New York, New York, for furnishing the X-Prep and Geigy Pharmaceuticals Division of Geigy Chemical Corporation, Yonkers, New York, for furnishing the Dulcolax used in this study.

In addition, we wish to thank Dr. G. R. Ridings, Professor and Head, Department of Radiology, The University of Oklahoma Medical Center, for his counsel and criticism.

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DIFFICULTIES IN THE ROENTGEN DIAGNOSIS OF CECAL TUMORS*

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THE roentgen demonstration of tumors in the cecum may be more difficult than in other parts of the colon where the diameter is smaller.^{1,2} This is particularly true of small tumors arising on the anterior or posterior wall, which are more difficult to visualize in profile. An analogy can be made with the rectum where small lesions are not easily demonstrable roentgenographically. However, the entire circumference of the rectum can be examined directly by the examining finger or the proctosigmoidoscope. The cecum, of equal or greater diameter, can only be examined indirectly, either in the distended state with a fluid barium suspension or barium and air, or in the contracted state by studying the configuration of the mucosal folds coated with barium.

The early recognition of cecal tumors is most important, since resection of these tumors, as well as tumors of the other segments of the colon, yields one of the best survival rates in diseases of the gastrointestinal tract.⁴ Unfortunately, tumors arising in the cecum are often "silent," with a paucity of early signs and symptoms unless they are complicated by bleeding, obstruction, intussusception, perforation or appendicitis.⁸

In the majority of cecal tumors a definitive tumor defect is usually revealed by one or more techniques. Yet, there is a sizable number of cases in which the tumor is not positively identified on roentgen examination. In a recent report the tumor was overlooked initially in 6 of 22 cases.³ The lesion was demonstrated subsequently in 2, but the remaining 4 were not correctly diagnosed before surgical exploration.

ROENTGEN SIGNS

We wish to call attention to the roentgen abnormalities presented by this group of tumors. When one or more of the following signs is present, a strong suspicion of tumor as the underlying cause must be entertained:

1. *Irritability.* The cecum may not relax initially to accept the barium stream or, following the initial filling, there may be rapid contraction. This makes it difficult to apply compression for the delineation of small defects. Both small and large tumors have frequently presented this finding. This irritability is sometimes overcome by the double contrast technique.

2. *Irregularity of Outline without a Definitive Filling Defect.* This may be the only abnormality on either the pre- or post-evacuation studies. However, this sign may be confused with adherent fecal material, which will also produce marginal irregularities or intraluminal defects. This emphasizes the need for a properly cleansed right colon.

3. *Shallow, Marginal Defects with Sharp Corners.* Sometimes these are only revealed on the double contrast study; they may be due to tumor infiltration.

4. *Irregular Mucosal Relief Pattern.* The mucosal staining on the postevacuation study may show thickened irregular folds even though the tumor is not recognizable.

5. *Lack of Cecal Filling.* Some of the largest tumors may grow through and around the cecum into the surrounding tissues, wholly or partly compressing and obliterating the lumen. Recognition of incomplete filling may be difficult, particularly when associated with irritability. In some cases a tumor filling defect is not evident on

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either pre- or postevacuation studies because the barium column did not enter the tumor area.

6. *Perforation with Para- or Pericecal Abscess Formation.* The tumor may perforate and produce an abscess or the abscess may result from perforation of the appendix secondary to occlusion of its base by the tumor. These abscesses produce defects in the cecal outline which may compress or obliterate the portion of the cecum containing the tumor, making correct assessment difficult.

The demonstration of any of these abnormalities, with confirmation by restudy, should strongly suggest tumor as the probable diagnosis, even in the absence of a palpable mass, and especially in the presence of anemia or occult blood in the stool.

The following case reports will serve to illustrate the difficulties in the roentgen diagnosis of certain cecal tumors by emphasizing the abnormalities and problems which may be encountered.

REPORT OF CASES

CASE I. M.D., a fifty-two year old white male. The diagnostic problem in this patient, who had a sudden onset of rectal bleeding, centered about the radiolucencies in the cecal tip which were interpreted as fecal material at the initial examination (Fig. 1, *A*, *B* and *C*). Since the terminal ileum was not filled, the patient was asked to return for a small bowel study, but he failed to do so. A few days later he developed an acute surgical abdomen with right lower quadrant pain. At operation this was found to be a perforated cecal tumor. The appendix was removed, but there was no colonic resection.

Two months later there was a palpable mass in the cecal area. A repeat colon study revealed only inability to completely fill the cecum and an indentation on the posterolateral wall. At oral barium study, the terminal ileum and ileocecal valve were normally outlined without evidence of displacement by the palpable mass.

Two months later, *i.e.*, four months after the initial onset of bleeding, a right colectomy was performed. A papillary ulcerated neoplasm 2.5 × 4.0 cm. in size was found at the tip of the cecum with extensive ulceration on the surface to a depth of 1.0 cm.

Comment. The episode of bleeding suggested the possibility of tumor, but it was not recognized at the initial colon study since the mottled radiolucencies at the cecal tip were misinterpreted as feces, an error of commission. A second study two months later did not positively identify the tumor, despite its known presence.

CASE II. J.W., a sixty-two year old white male. This patient had mild anemia, inconstant occult blood in the stool and a questionable soft mass in the right lower quadrant. The diagnostic problem centered about the partially contracted and incompletely distensible cecum (Fig. 2, *A*, *B* and *C*). A tumor mass involving the wall could not be positively identified. The contracted cecal tip suggested inflammatory disease but, in the presence of anemia and the absence of fever, tumor seemed more likely.

At surgery, an adenocarcinoma 4.0 cm. in diameter was found in the anterior portion of the cecal tip. Grossly, this fungating mass had infiltrated the entire wall and the underlying fat.

Comment. In this case the tumor mass was not identifiable on roentgen examination, but an abnormal cecum in the presence of anemia, occult blood and a questionable mass suggested tumor as the correct diagnosis.

CASE III. J.H., a seventy year old white male. The diagnostic problem concerned the mottled densities overlying the right iliac fossa which were interpreted as fecal masses in a compressed cecum (Fig. 3, *A* and *B*). There was a large, tender, slightly fluctuant, palpable mass over this area.

Three weeks prior to the examination there had been a sudden onset of pain in the right lower quadrant. Fever, anemia and leukocytosis were present. The clinical and roentgen findings suggested ruptured appendix with abscess and, at surgery, a foul, fecal smelling, orange-sized abscess was drained. Postoperative drainage diminished but was intermittent for two and one half months, and the patient was re-operated. The drainage site was opened widely and deeply. Some necrotic tissue was found to extend to the cecal wall. Frozen sections revealed carcinoma and a right hemicolectomy was performed. The cecum showed an ulceration on the lateral wall which had perforated into the adjacent tissues.

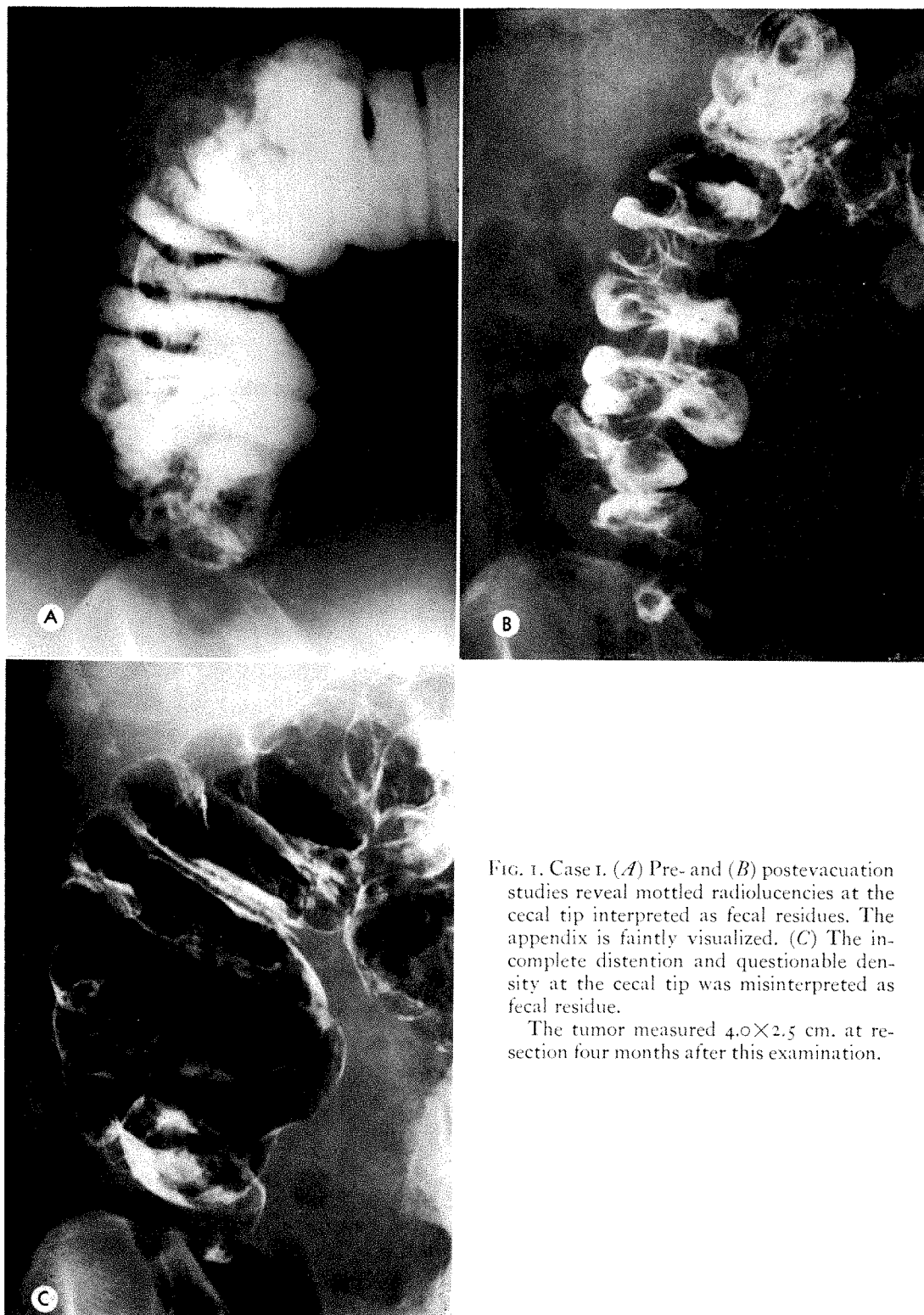


FIG. 1. Case I. (A) Pre- and (B) postevacuation studies reveal mottled radiolucencies at the cecal tip interpreted as fecal residues. The appendix is faintly visualized. (C) The incomplete distention and questionable density at the cecal tip was misinterpreted as fecal residue.

The tumor measured 4.0×2.5 cm. at resection four months after this examination.

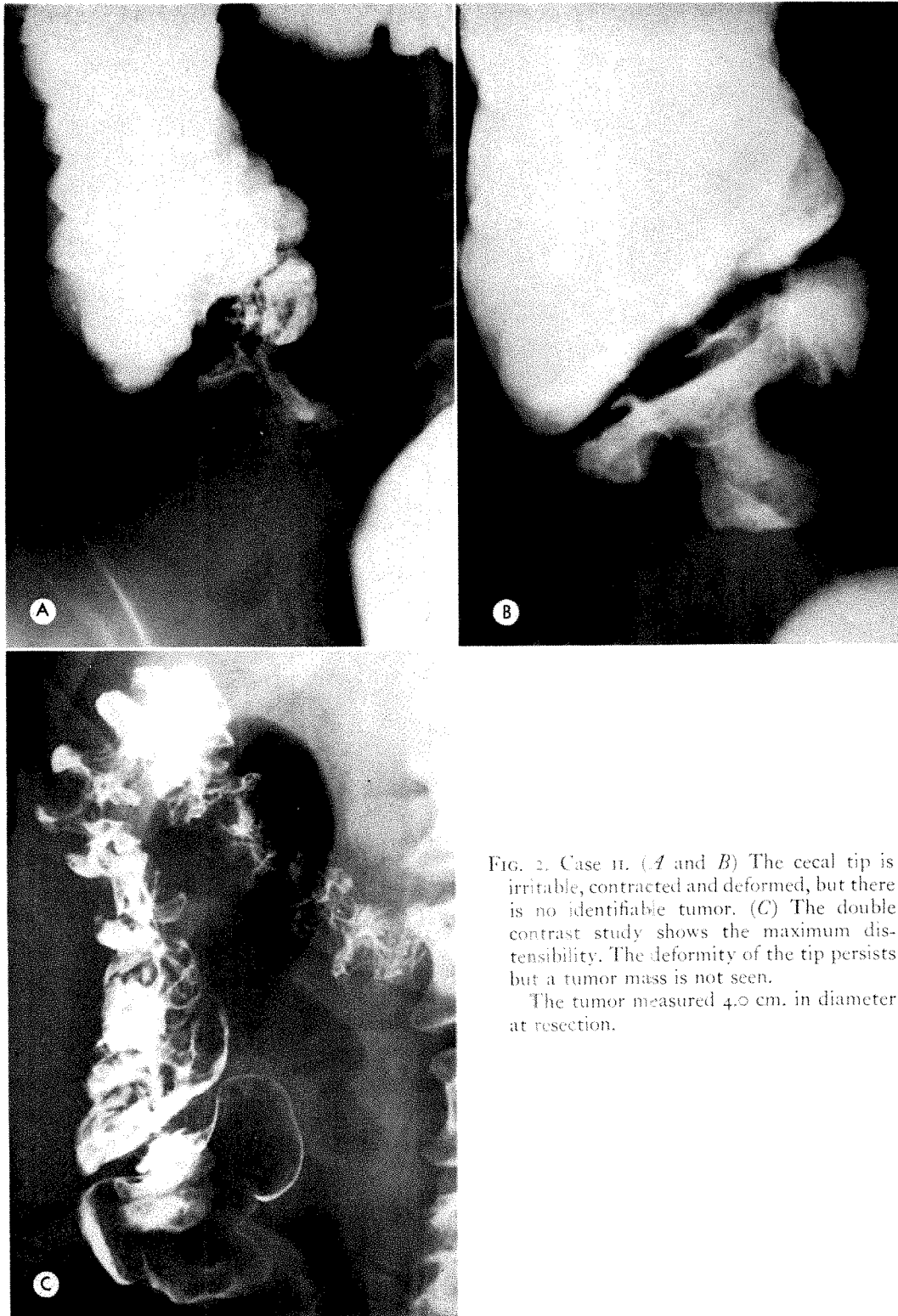


FIG. 2. Case II. (*A* and *B*) The cecal tip is irritable, contracted and deformed, but there is no identifiable tumor. (*C*) The double contrast study shows the maximum distensibility. The deformity of the tip persists but a tumor mass is not seen.

The tumor measured 4.0 cm. in diameter at resection.

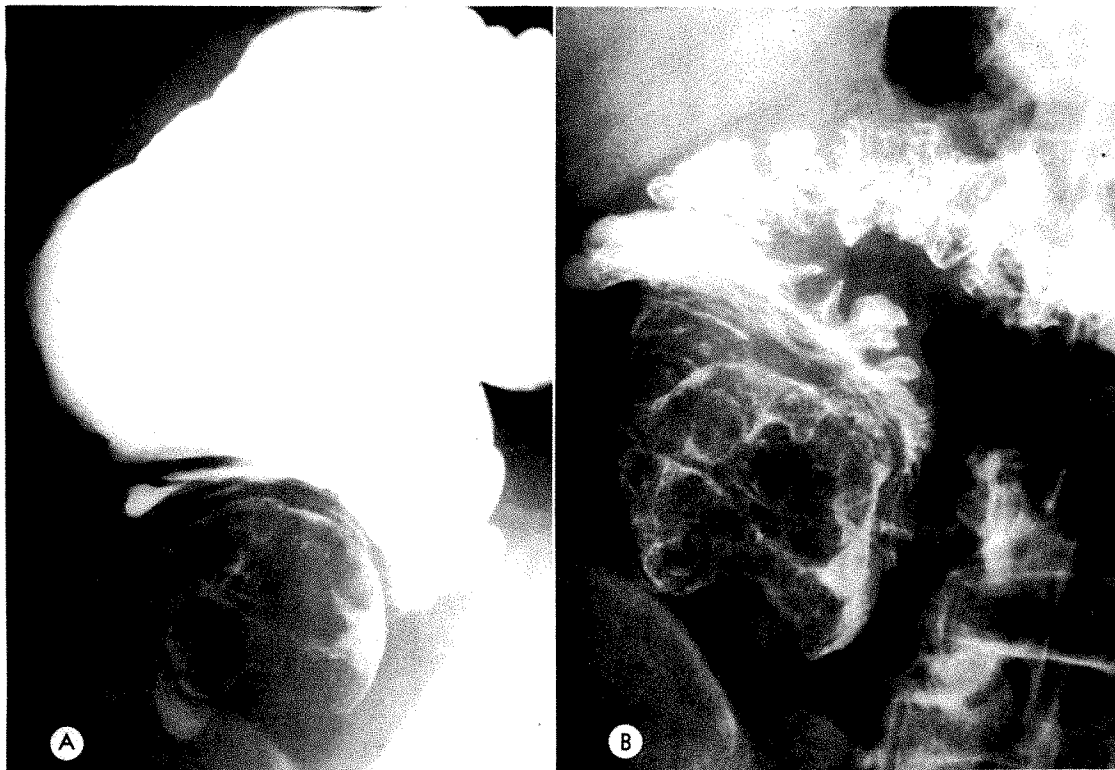


FIG. 3. Case III. (A) Pre- and (B) postevacuation roentgenograms show that the cecum is incompletely filled due to compression by the clinically palpable, large, fluctuant mass. The mottled radiolucencies in the cecal area were interpreted as retained fecal masses. Note the sharp delineation between the compressed cecum and the ascending colon.

The compressed cecum measured 6.0 cm. in diameter but the tumor measured only 3.0×4.0 cm. at resection two and one half months after this examination.

The specimen revealed a fungating, perforating tumor only 3.0×4.0 cm. in size adjacent to the appendiceal base, infiltrating all layers and the outer fat. The appendix showed serosal inflammatory changes.

Comment. The early perforation of this tumor obscured the underlying cause and produced clinical and roentgen abnormalities interpreted as an appendiceal abscess with cecal compression. The mottled cecal densities and moderate anemia should have suggested the possibility of tumor.

CASE IV. J.L., a fifty-nine year old obese white male. The diagnostic difficulty in this patient was related to the filling of the cecum at the time of fluoroscopic observation. The cecum did not immediately relax to accept the oncoming barium stream. At the time of apparent maximum filling, a spot roentgenogram showed

irregularities of the cecal tip and posterior wall which were not recognized as tumor. Due to the irritability, the pre-evacuation studies showed a partially contracted cecum with distorted mucosal folds (Fig. 4). The postevacuation study also showed distortion of the folds over a fairly large area of the cecum and ascending colon, but a tumor was not recognized.

For three months prior to the examination, there had been constant discomfort and pain in the lower abdomen, with occasional cramps at night. The liver was somewhat enlarged but no nodules were felt. Anemia of moderate severity was present.

At surgery, a large mass composed of a cecal tumor and matted small bowel was found in the right lower quadrant. Multiple tumor nodules involved the mesentery and extended down to the base. The liver was markedly enlarged and full of metastatic tumor. Biopsy revealed a mucus-secreting adenocarcinoma.



FIG. 4. Case IV. Note the distorted thickened folds in the partially contracted cecum. The indentation on the medial wall (arrow) was interpreted as a plump ileocecal valve.

This large tumor of the cecum was inoperable.

Comment. The irritability, incomplete filling of the cecal tip, distortion of the mucosa and the presence of anemia should have suggested a cecal tumor, even though a tumor filling defect was not recognized or was interpreted incorrectly.

CASE V.* T.M., a fifty-five year old white male. The difficulty in diagnosing this case was based upon the incomplete filling of the cecum on the colon study and inability to visualize the terminal ileum adequately on the small bowel study; this resulted in the roentgen interpretation of possible granulomatous inflammatory disease (Fig. 5, A, B and C).

There was a long history of periodic indigestion, considered to be functional in view of negative results of repeated clinical, laboratory

and roentgen studies. Six weeks prior to admission, there had been a definite change with cramps, abdominal pain, anorexia, loose stools, loss of weight and malaise. Physical examination was essentially negative except for tenderness in the epigastrium and right lower quadrant. No masses were felt. There was no anemia but the sedimentation rate was 23 mm. The stools were negative for occult blood.

At surgery, a penetrating carcinoma of the cecum with fixation to the right abdominal wall was found. There was involvement of the terminal ileum and omentum with numerous implants in the cul-de-sac. The liver was diffusely involved with metastatic carcinoma.

A primary tumor of the cecum involving almost its entire circumference was found at autopsy. In addition to the dissemination noted at the surgical exploration, there were metastases in all of the abdominal and thoracic organs.

Comment. The irritability of the involved cecum and terminal ileum suggested inflammatory or granulomatous disease as the primary diagnosis, since constant filling defects were not discerned at the roentgen examination. There was no anemia and the stools were negative for occult blood.

CASE VI. P.E., a fifty year old white male. This patient had a two months' history of shooting pains in the right abdomen, more severe during the three weeks prior to examination. The diagnostic problem centered about the incompletely filled cecum with a bubble of gas just below it (Fig. 6, A and B). On the postevacuation study, the terminal ileum filled and showed some displacement (Fig. 6 B). A tumor involving the cecum was not identified on either the pre- or postevacuation studies. Thus, in the absence of an identifiable tumor, the findings suggested inflammatory disease such as indolent appendiceal abscess. Rectally, a hard, irregular, nonfluctuant, nontender mass was felt at the tip of the examining finger on the anterior wall a little to the left of the midline. Slight fever was present, but there was no anemia or weight loss.

Surgery revealed a large cecal tumor extending upward to involve the ascending colon and downward into the right pelvis. The omentum was studded with tumor. No abscess was found. Biopsies from several areas revealed a mucus-secreting adenocarcinoma.

* This case is reported through the courtesy of Dr. Gordon Culver, Buffalo General Hospital, Buffalo, New York.

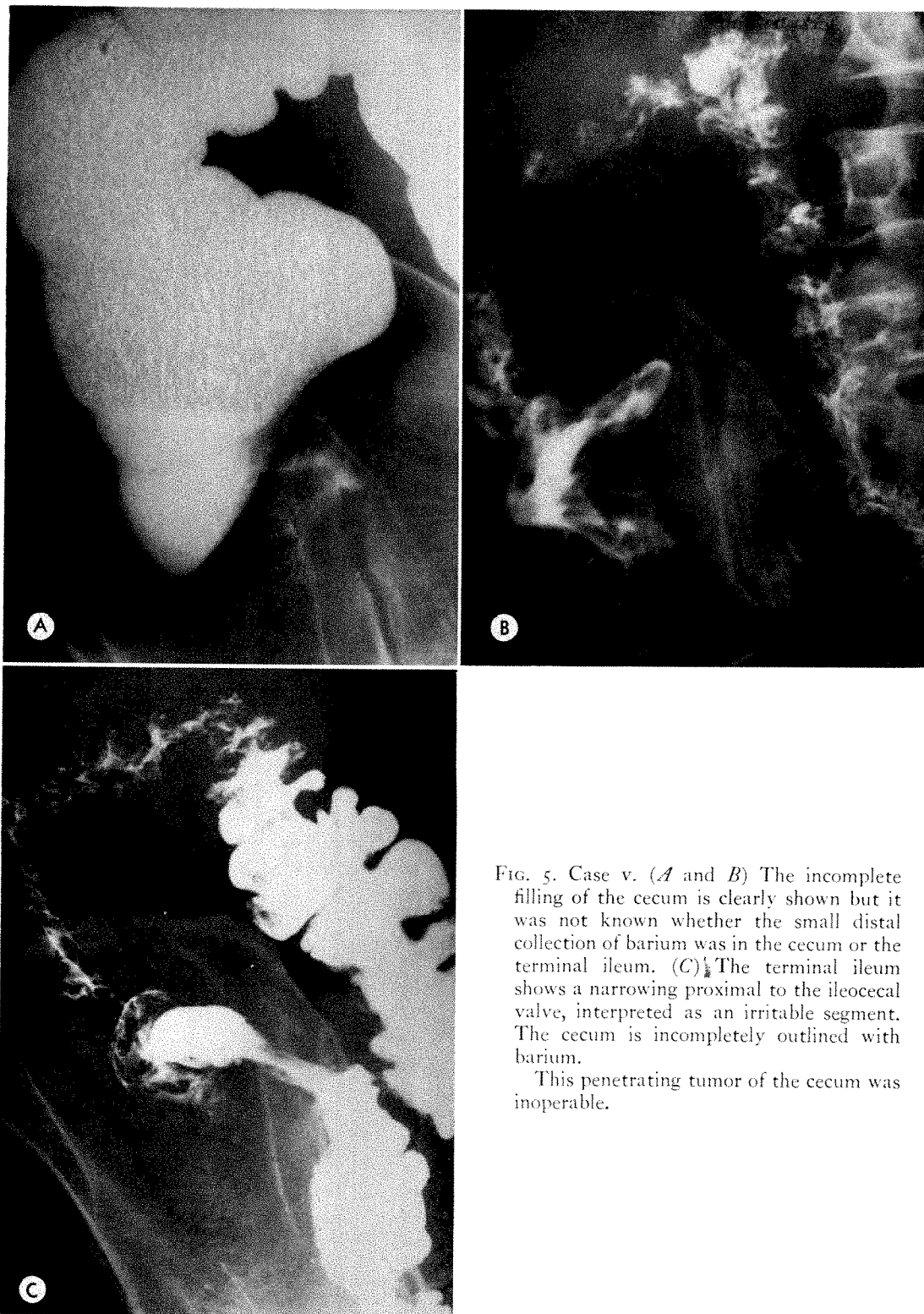


FIG. 5. Case v. (A and B) The incomplete filling of the cecum is clearly shown but it was not known whether the small distal collection of barium was in the cecum or the terminal ileum. (C) The terminal ileum shows a narrowing proximal to the ileocecal valve, interpreted as an irritable segment. The cecum is incompletely outlined with barium.

This penetrating tumor of the cecum was inoperable.

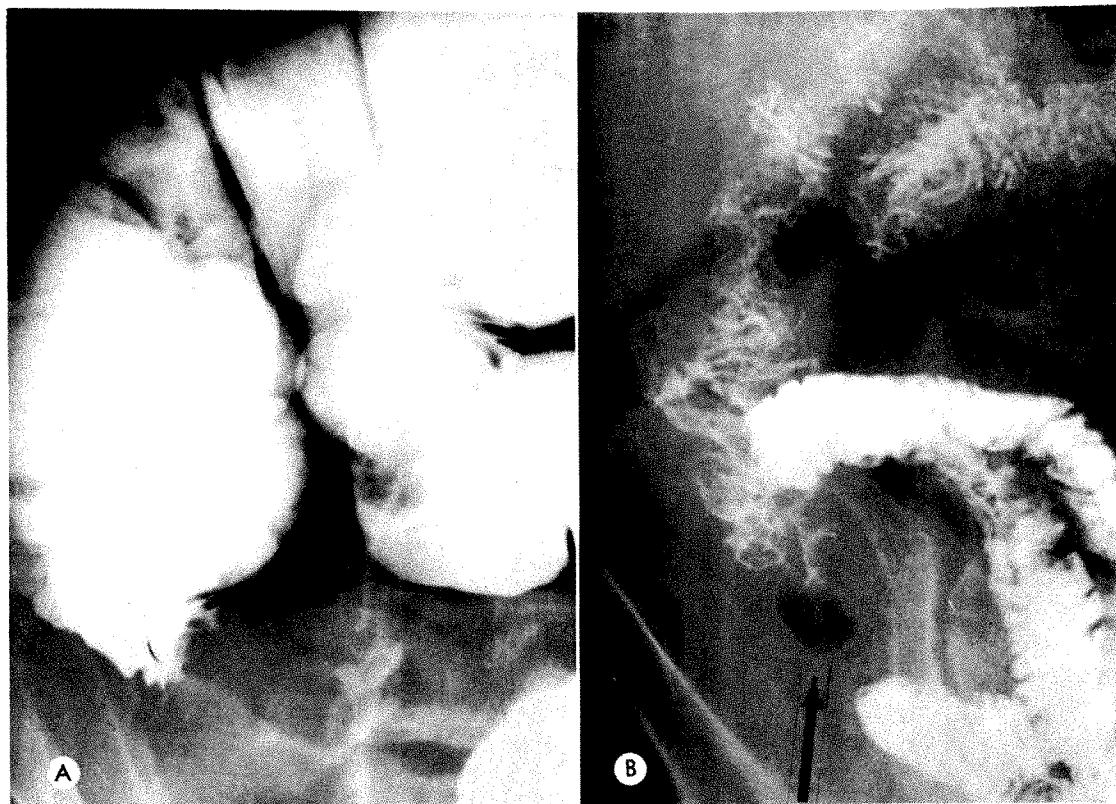


FIG. 6. Case VI. (A) The cecum is incompletely filled with barium. (B) The postevacuation study shows contraction of the incompletely filled cecum and the bubble of gas below it (arrow). The terminal ileum is displaced.

An extensive inoperable tumor was found at surgery.

Comment. Although an extensive tumor mass involving the cecum and ascending colon was found at surgery, the colon study had not revealed the extent of the cecal involvement since the barium had not extended far enough into the cecum to allow visualization of a tumor. The gas bubble may have been trapped in a segment of the unfilled portion of the cecum.

CASE VII. C.J., a sixty year old white female. There was a long history of constipation and indigestion, a twenty pound weight loss over a six to eight month period and persistent anemia. The diagnostic problem in this patient was related to the irritable segment at the junction of the cecum and ascending colon (Fig. 7A). The initial roentgen study and the repeat study, a week later, showed spasm and irritability at this location with a large amount of retained fecal material in the right colon (Fig. 7, A and B). A tumor was not identified on

the postevacuation studies of the partially contracted cecum, although there were exaggerated haustral folds along the lateral wall (Fig. 7C). However, air contrast studies (Fig. 7, D and E) revealed in the right anterior oblique projection a step-like defect on the lateral and posterior wall of the suspicious zone. Below this, as far as the cecal tip, the wall was slightly serrated. This step-like deformity and serration were interpreted as tumor infiltration.

At surgery, a tumor of the cecum 4 cm. in diameter, involving the ileocecal valve, was found and a right hemicolectomy was performed.

Comment. The first and second roentgen examinations were suggestive of inflammatory disease and a distinct tumor was not identified. The double contrast study revealed a step-like deformity of one wall, suggesting tumor infiltration, but the mass itself was not clearly outlined. The com-

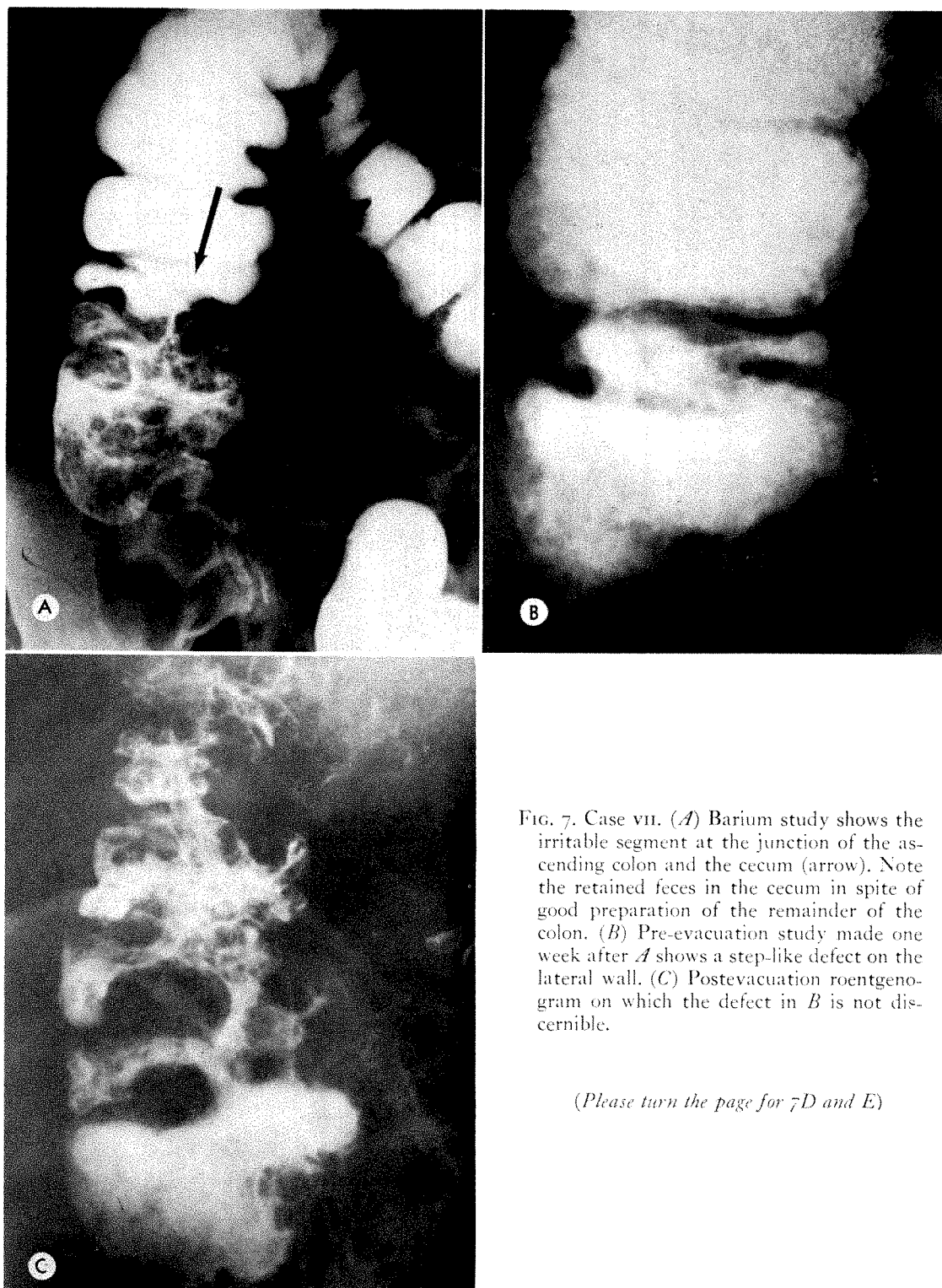


FIG. 7. Case VII. (A) Barium study shows the irritable segment at the junction of the ascending colon and the cecum (arrow). Note the retained feces in the cecum in spite of good preparation of the remainder of the colon. (B) Pre-evacuation study made one week after A shows a step-like defect on the lateral wall. (C) Postevacuation roentgenogram on which the defect in B is not discernible.

(Please turn the page for 7D and E)

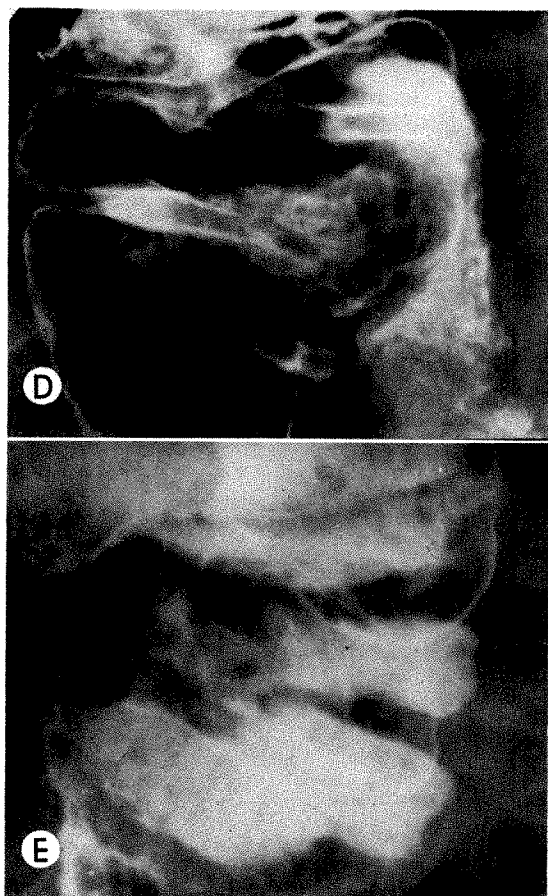


FIG. 7. (*D* and *E*) Double contrast spot roentgenograms. The defect is not visualized in the anteroposterior view (*D*) but is clearly seen in a right anterior oblique projection (*E*). This confirms the defect noted in *B*.

The tumor measured 4.0 cm. in diameter.

bination of irritability, step-like defect on distention, anemia and occult blood suggested that tumor was the correct diagnosis.

CASE VIII. S.H., a seventy-eight year old white male. The problem in the roentgen diagnosis centered about the initial irritability of the cecum at the time of the barium enema. The cecum could be distended, but there was a flat step-like indentation on the lateral wall on both the barium and double contrast studies (Fig. 8, *A* and *B*).

Three months previously, a roentgenographic examination of the colon had been reported as negative but, on review, the step-like indenta-

tion on the lateral wall was seen to have been present (Fig. 8, *C* and *D*). During this three month interval a physical examination was essentially negative, but there was intermittent occult blood in the stool and a drop in the hemoglobin from 12.5 to 10.5 gm. The association of these clinical findings with the cecal irritability and step-like indentation seen on roentgen examination suggested tumor. The patient was advised to have surgery, but refused.

Surgery was not performed until approximately nine months later. During this time, the colon was re-examined on three occasions, *i.e.*, two, six (Fig. 8*E*) and seven and one half months after surgical intervention was advised. On each occasion the major finding was cecal irritability and lack of distensibility during the retrograde barium study. The postevacuation studies revealed thickening and coarseness of the mucosal pattern but a definite fixed deformity was not demonstrated or recognized. Double contrast studies revealed distensibility of the cecum with a step-like indentation on the lateral wall. On the last two occasions, there was slight raggedness along the lateral wall as well.

A fungating tumor penetrating through the lateral wall, involving the lateral parietal peritoneum, was found at surgery and a right hemicolectomy was performed.

The tumor measured only 3.0×5.0 cm. and one edge involved the ileocecal valve. It had infiltrated the entire wall and extended into the underlying fat tissue. Sections showed a mature adenocarcinoma infiltrating all areas.

Comment. The diagnosis of cecal tumor was correctly suggested at the time of the second examination by the association of the clinical and roentgen findings noted above, despite the absence of a typical tumor filling defect. The procrastination of the patient afforded the opportunity for several re-examinations in which the most prominent findings were again irritability of the cecum, thick and irregular mucosa when contracted and a small step-like defect on the lateral wall when distended by the double contrast technique.

DISCUSSION

The common denominator in this selected group was an abnormality of the cecum,

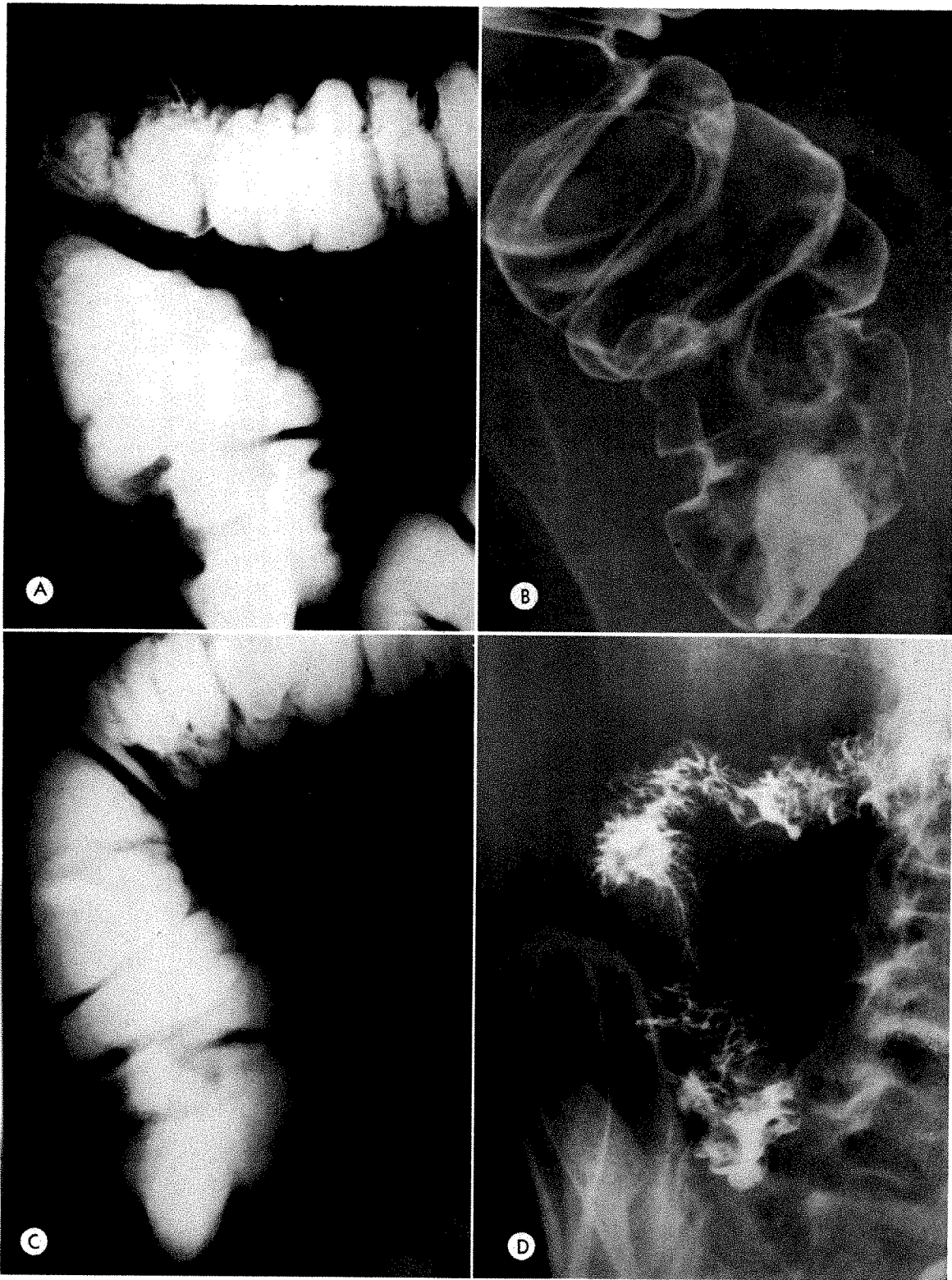


FIG. 8. Case VIII. (A) Barium and (B) double contrast studies show the step-like indentation on the lateral wall. (C) Barium and (D) postevacuation studies performed three months prior to A and B. The significance of the step-like defect was not recognized in view of the apparently normal mucosa of the contracted cecum.

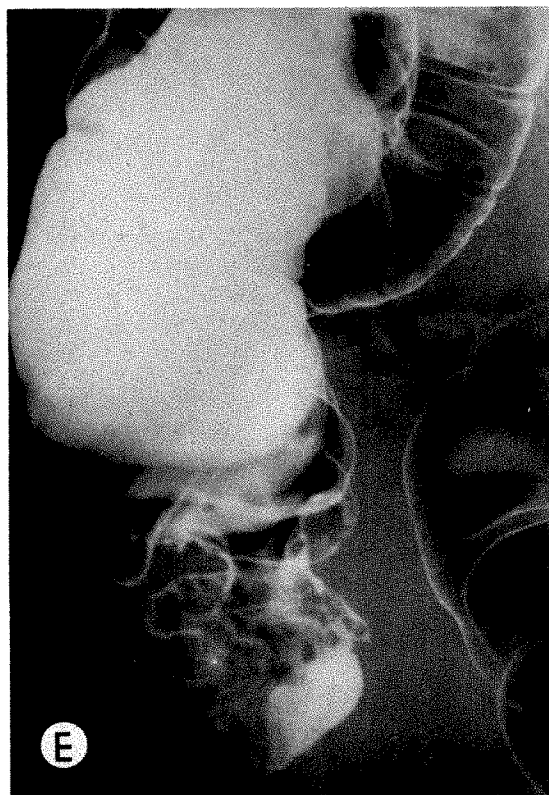


FIG. 8. (E) Barium study six months after A. The cecum is still fairly distensible but there is incomplete filling along the lateral wall without a definitive tumor defect.

The tumor measured 3.0×5.0 cm. at surgery twelve months after the initial examination (C and D).

but the correct interpretation of tumor was not made in every case. Due to the frequency of irritability, the exclusion of inflammatory disease presented the most common problem in the differential diagnosis. Phillips *et al.*⁶ found that 17 of 27 benign lesions of the cecum (misdiagnosed as carcinoma) were due to inflammatory disease. Weber⁹ has stated, "the diagnosis of inflammatory disease is made after eliminating the possibility of tumor."

The most frequent possibility to be considered in the differential diagnosis is acute or subacute perforated appendicitis. Appendiceal abscess *per se* is not uncommon in older age groups, but it may also result from appendicitis secondary to oc-

clusion of the base by a tumor.⁵ Other acute or chronic inflammatory lesions to be differentiated are segmental nonspecific ulcerative colitis of the right colon, specific colitis due to tuberculosis or amebiasis, right sided diverticulitis and foreign body perforation.^{1,10} The presence of small fecal masses may be confused with small benign or malignant tumors in spite of careful preparation, and must be differentiated by a repeat examination.

Anemia and occult blood in the stool were present in the majority of cases but were absent in Cases iv and v, which had extensive tumors. Palpable abdominal masses were noted in only 2 of the 8 cases and of these 1 was due to an abscess. In Case vi a nodular mass was felt rectally. Thus, the clinical signs were inconstant; however, the fact that anemia and occult blood in the stool were the most common emphasizes their importance in the absence of other signs or symptoms.

SUMMARY

The presence of a tumor should be suspected when any of the following roentgen abnormalities of the cecum are demonstrated: (1) irritability, (2) irregularity of outline without a definite filling defect, (3) shallow, marginal defects with sharp corners, (4) irregular mucosal relief pattern, (5) lack of cecal filling in whole or in part, and (6) defects due to para- or pericecal abscess. These findings are particularly significant in any patient over forty years of age and especially in the presence of anemia or occult blood.

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ADDENDUM

After reviewing our Scientific Exhibit at the Sixty-first Annual Meeting of the American Roentgen Ray Society, Dr. Isadore Sedlezky, Radiologist-in-Chief at the Jewish General Hospital, Montreal, Quebec, Canada, was kind enough to send

us roentgenograms of 2 cases showing sharply cornered, localized shallow marginal defects, similar to those seen in Cases VII and VIII, which at surgery proved to be carcinoma.

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RETROGRADE PROLAPSE OF THE ILEOCECAL VALVE

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SINCE the advent of amplified fluoroscopy, retrograde prolapse of the ileocecal valve has been seen with greater frequency. Antegrade prolapse of the terminal ileum has been reported by many authors, some considering this a normal physiologic state and others a pathologic entity. It is not our intent to add to the discussion regarding these controversial concepts, but rather to emphasize the importance of being cognizant of the reverse movement of the valvular mucosa, since the appearance can be confusing and lead to errors in interpretation. This very problem induced Rigler and Lasser² to report a case in 1951.

REPORT OF A CASE

R.R., fifty-three years of age, was first seen on October 16, 1953, at which time a general examination revealed a healthy white male with no abnormal physical findings. The only abnormality was a slightly elevated blood sugar level.

On July 3, 1956, a prostatic resection and a bladder papillectomy were performed. In September, 1958, the patient sought medical advice because he had noted occasional loose stools.

Physical examination revealed vague tenderness elicited at deep palpation in the cecal area. Sigmoidoscopic study demonstrated a smooth rectal mucosa but the watery stool was serosanguinous. The test for blood was 4+. A double contrast roentgen study of the colon revealed a negative colon pattern but demonstrated a prominent ileocecal valve (Fig. 1). The mucosa was seen to enter the cecum and then to extend back in a retrograde manner into the ileum (Fig. 2). The V shaped frenulum was not disturbed or effaced.

On December 8, 1958, the patient noted red blood, mixed with the excreta, in a loose stool. All the laboratory studies were noncontributory.



Fig. 1. Spot roentgenogram demonstrating the prominent valve which has prolapsed into the cecum.

A repeat colon study again demonstrated retrograde prolapse of the mucosa and, although the mucosa appeared pliable and suggested a benign state, the patient was explored. We felt this was justified because of the persisting melena and because we could not exclude the possibility of a small neoplasm. The surgical specimen demonstrated the redundancy of the mucosa which was so alterable as to permit simulation of the *in vivo* conditions (Fig. 3).

DISCUSSION

Anatomically, the terminal ileum enters the colon on the medial aspect at right angles to the ascending caput; the bluntly rounded ends of the ileal walls form the upper and lower lips of the valve (Fig. 4). The upper lip is the longer (approximately 2 cm. in length) and is well delineated in spot roentgenograms made of this region. The common lower ileocecal wall bends medially to form the lower lip of the valve by approaching the upper lip at an acute angle and by ending a few millimeters short

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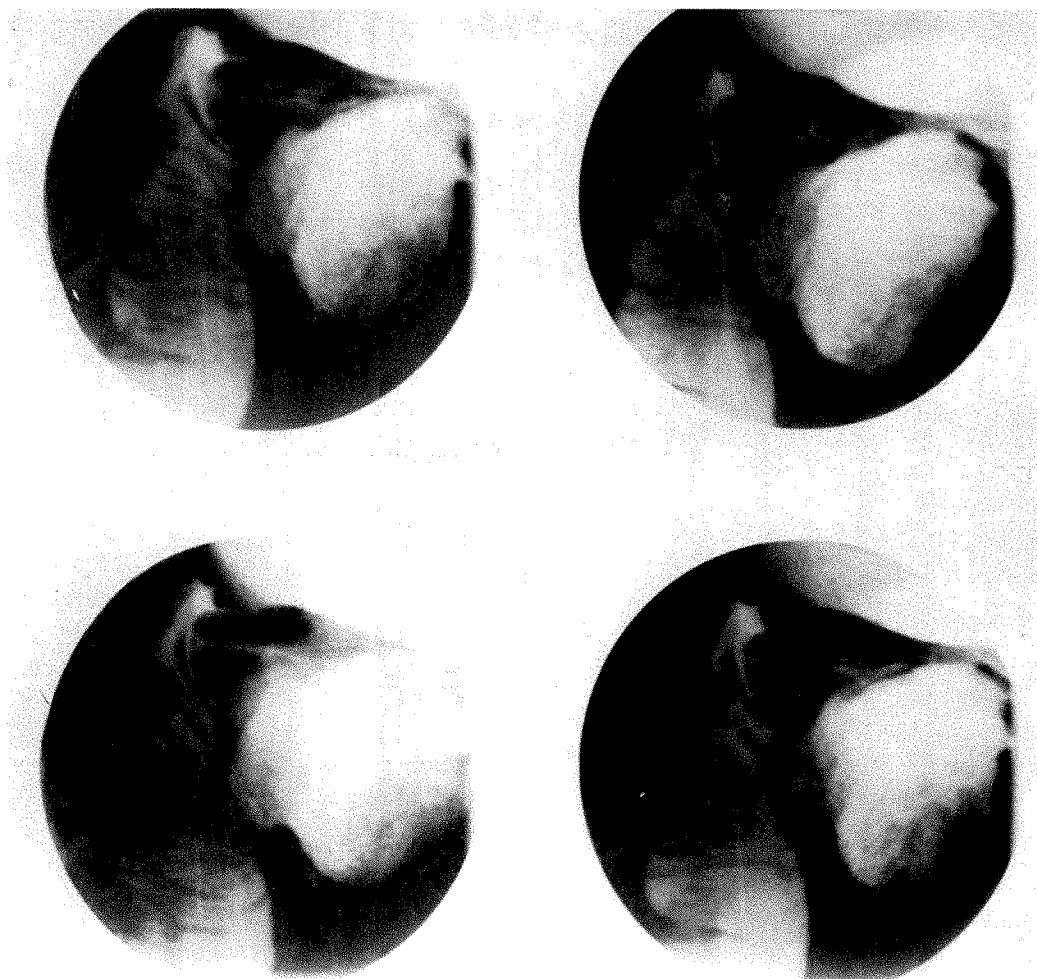


FIG. 2. Spot roentgenograms demonstrating the retrograde mucosal prolapse. Note that the V shape of the valve is not obliterated; this emphasizes the mucosal basis for the roentgen findings.

of it. The valve, as such, does not project freely into the colon, but it is supported and suspended by crescentic folds of the colonic wall called the frenula of the valve. Since the ileum is usually implanted into the colon immediately anterior to the medial mesenteric tenia, this tenia softens the base of the valve while the lateral tenia lends support to the frenula. The mucous membrane of the lips is often loosely attached to the underlying structure and this is especially true of the inner surface of the ileal valve (Fig. 3).

Fleischner and Bernstein¹ have dissected multiple anatomic specimens from which they have concluded that the protrusion of the ileocecal valve is caused by the re-



FIG. 3. Surgical specimen showing the redundant ileal mucosal fold and a small superficial ulceration (arrows). The mucosa was readily movable and could be prolapsed in either direction.

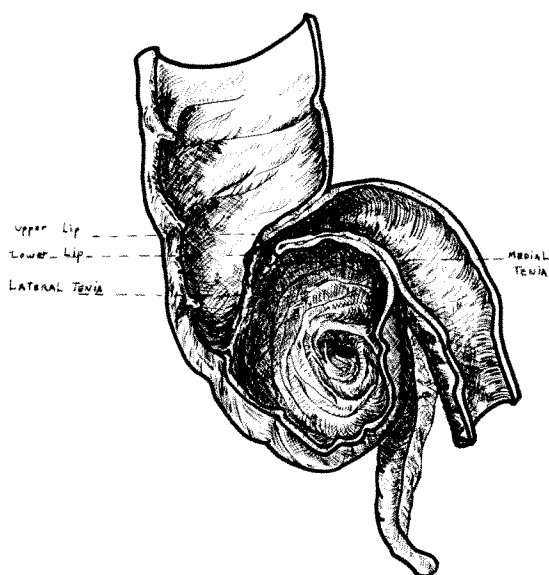


FIG. 4. Line drawing of the ileocecal valve.

dundant ileal mucosa. This rosette-like valve is compared to the prolapse of the antral mucosa into the duodenum.

Our roentgen findings support Fleischer and Bernstein's anatomic findings since, in the roentgen study of retrograde prolapse, the indented "beak-like" valvular shadow persists while a small linear channel of barium is observed in the ileocecal area. The mucosa seems to move backward as the barium is forced into the ileum. This phenomenon may persist for several seconds at fluoroscopy even though the flow of barium is stopped. It can readily be explained by the difference in pressure gradient within the lumen of the cecum and ileum. The persistence of the valvular appearance at the cecal area without any

effacement associated with extreme distention precludes considering the valve alone as being responsible for the roentgen appearance.

Although this condition is unassociated with clinical or physical findings in most instances, and its roentgen and fluoroscopic observation is a fortuitous one, occasionally active bleeding may be the presenting complaint, or there may be occult blood loss. The diagnosis becomes further complicated by the rare coexistence of mucosal ulcers and redundant ileal mucosa, such as occurred in the reported case.

SUMMARY

1. The concept of retrograde mucosal prolapse of the ileocecal valve is presented as a physiologic phenomenon that is confronting the radiologist with increasing frequency since the advent of amplification fluoroscopic techniques.

2. On rare occasions, the redundant mucosa may contain some small ulcers that can account for occult and active bleeding.

3. Recognition of this condition may help one avoid the misinterpretation of these roentgen findings.

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A HISTOPATHOLOGIC BASIS FOR THE INTERPRETATION OF SMALL BOWEL ROENTGENOGRAPHY IN TROPICAL SPRUE*

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INTRODUCTION of the peroral small bowel biopsy² has made possible histologic study of the small intestine in various disease states. Utilizing this technique, Butterworth and Perez-Santiago¹ documented the jejunal mucosal pathology in tropical sprue. The most prominent changes are epithelial cell abnormalities, villous atrophy, and round cell infiltration. The pattern of malabsorption in sprue has been defined by poor xylose absorption, low serum carotene levels, poor absorption of vitamin A and test fats, and steatorrhea.⁷ Another important diagnostic procedure in tropical sprue is small bowel roentgenography with barium. This reveals many abnormalities that are difficult to interpret, not only in tropical sprue, but also in nutritional, metabolic and functional disorders.⁹ The peroral small intestinal biopsy makes possible the correlation of pathologic changes with the roentgen series. In this investigation we have compared the biopsy specimens, biochemical tests and barium examination of the small bowel in tropical sprue.

METHODS

Eighteen patients with tropical sprue were included in this study. Twelve were untreated and 6 were treated. At the time of this study the treated patients were in clinical remission from two to eight years, as a result of folic acid and/or vitamin B₁₂ therapy. The diagnosis of tropical sprue was based on the presence of glossitis, weight loss, diarrhea, steatorrhea, megaloblastic anemia, and impaired absorption of fat, xylose and vitamin A.

All patients were admitted to the meta-

bolic ward of the U. S. Army Tropical Research Medical Laboratory, and during the study were maintained on a diet containing 90–110 gm. of fat daily. In addition to the usual work-up, the following tests were performed: a 5 gm. xylose absorption test;¹⁷ a fasting carotene level;¹³ a vitamin A absorption study¹³ in which 300,000 units were ingested with fasting, five and seven hour blood levels measured to determine the peak level;¹⁴ a fat balance study in which a seven day average fecal excretion of chemical fat²² was determined; a bone marrow study in untreated cases; a peroral biopsy of the upper one-third of the jejunum with the Crosby capsule;² and a small bowel barium examination in which 8 ounces of liquid containing 5 ounces of colloidal barium (and tap water to volume) was ingested. Roentgenograms were taken immediately and at fifteen, thirty, sixty minutes and serially until the cecum was visualized.

To facilitate correlation of data the roentgen and biopsy specimen abnormalities were graded as follows: Grade 1—signifying a slight or minimal, but definite change; Grade 2—meaning a moderate change; and Grade 3—a severe abnormality.

The small intestinal series were graded for loss or flattening of folds, flocculation of barium, puddling of barium, and segmentation of barium filled loops of bowel. A jejunal loop measuring greater than 3.0 cm. in diameter was considered dilated, as was an ileal loop of more than 2.5 cm.⁹ Mouth to cecal transit time and gastric emptying time were also recorded.

The biopsy specimens were graded for:

* From the U. S. Army Tropical Research Medical Laboratory and Rodriguez U. S. Army Hospital, Fort Brooke, San Juan, Puerto Rico.

(a) atrophy, by evaluating fusion and shortening of villi; (b) inflammation, as evidenced by infiltration of lymphocytes, plasma cells and polymorphonuclear leukocytes; (c) goblet cell increase, and (d) epithelial integrity, by evaluating cell size and nuclear arrangement.

RESULTS

The results of the hematologic, absorption, roentgen and biopsy specimen studies obtained from the 18 patients are recorded in Table 1.

A. UNTREATED PATIENTS (NUMBERS 1-12 IN TABLE 1)

All 12 untreated patients had a megaloblastic bone marrow with anemias ranging from 3.4 to 10.1 gm. of hemoglobin. The degree and per cent of abnormality of the absorption tests are shown in Table 1 and Figure 1. Almost without exception the biochemical tests were markedly abnormal. Patient 3 had no fecal fat determination. Patient 8 was on intravenous feedings with no appreciable food intake. Patient 9 almost reached a normal vitamin A level, but had severe steatorrhea and impaired xylose absorption.

All the untreated patients had markedly abnormal small bowel roentgenograms. No specific pattern was noted. Each individual case varied in the type and degree of abnormality noted. For example, in patient 2, severe flocculation, moderate loss of folds and segmentation, slight dilatation and no puddling were observed (Fig. 2), whereas severe loss of folds and dilatation, with slight puddling and segmentation, and no flocculation were observed in patient 3 (Fig. 3). Patient 4 exhibited severe puddling, moderate loss of folds and segmentation, slight flocculation and no dilatation (Fig. 4). All of these patients had some degree of loss of folds, 11 of 12 exhibited flocculation, puddling and segmentation of barium, and half had dilated loops of bowel (Fig. 1). The mean transit time was three hours. The mean gastric emptying time was one hour and forty-five minutes.

The jejunal biopsy was moderately, or severely abnormal in all untreated patients. The degree and total per cent of abnormality are shown in Figure 5. All exhibited marked atrophy, inflammation, and epithelial changes (Fig. 6, 7 and 8). A goblet cell increase (Fig. 7) was noted in 9 of 12 patients.

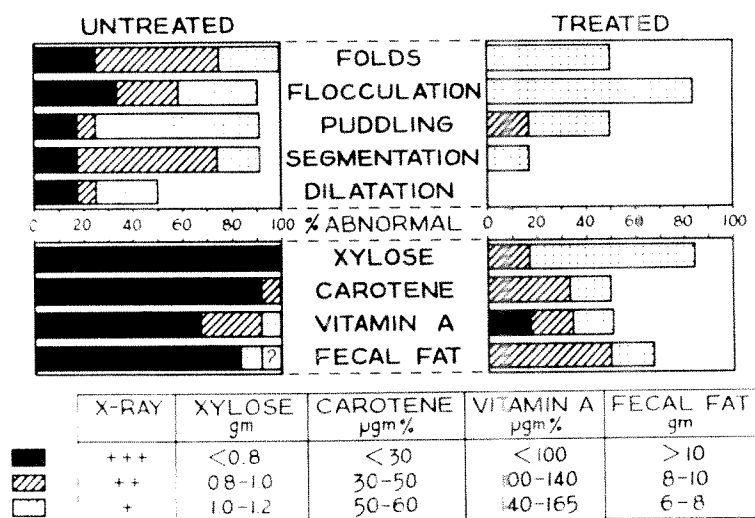


FIG. 1. Comparison of total per cent and degree of abnormality observed in absorption tests and on roentgenograms in untreated and treated patients with tropical sprue. The criteria for gradings of absorption test results are listed. (One patient had no fecal fat determination.)

TABLE I
RESULTS OF HEMATOLOGIC STUDIES, ABSORPTION TESTS, ROENTGEN AND
BIOPSY FINDINGS IN PATIENTS WITH TROPICAL SPRUE*

Patient No.	Hematology		Absorption Tests				Roentgen Findings							Biopsy Findings				
	Hb. (gm. per cent)	Hct. (per cent)	Megalo-blastic Bone Marrow	Xylose 1.5±.3 (gm.)	Fecal Fat (<6 gm.)	Carotene 120±60 (μg. per cent)	Vitamin A >165 (μg. per cent)	Folds	Flocculation	Pudding	Segmentation	Dilatation	Transit Time (hr.)	Gastric Emptying (hr.)	Atrophy	Inflammation	Goblet Cell	Epithelial Integrity
Untreated																		
1	7.8	24	+	0.3	26.6	26	37	++	++	+	+	0	2	1½	++	++	++	++
2	6.9	21	+	0.5	15.5	3	64	+++	++	0	+	+	5	1	++	++	++	++
3	6.4	20	+	0.5	—	46	101	+++	++	+	+	++	2	2	++	++	++	++
4	3.4	12	+	0.5	28.8	20	60	+++	++	+	+	+	2½	2½	++	++	++	++
5	6.0	24	+	0.2	35.3	19	60	+++	++	+	+	+	2½	2½	++	++	++	++
6	9.4	32	+	0.3	34.7	13	43	+++	++	+	+	+	½	2	++	++	++	++
7	5.6	16	+	0.7	16.8	15	107	+++	++	+	+	+	4	2	++	++	+	++
8	5.8	19	+	0.3	6.4	19	39	+++	++	+	+	0	4	2	++	++	0	++
9	8.0	24	+	0.4	32.3	19	163	+++	++	+	+	0	5	1	++	++	0	++
10	10.1	32	+	0.7	24.7	19	116	+++	++	+	+	+	4	2	++	++	+	++
11	5.4	17	+	0.2	26.5	6	36	+++	++	+	+	++	4	1	++	++	++	++
12	7.8	27	+	0.4	33.6	10	72	+++	++	+	+	0	2	1	++	++	+	++
Treated																		
13	14.2	44		1.2	8.6	102	102	0	+	+	0	0	2	5	++	++	0	++
14	15.5	43		1.0	10.0	32	35	+	+	+	+	0	3	3	++	++	0	++
15	14.2	46		1.0	9.8	173	819	+	+	+	+	0	2½	2	0	+	0	0
16	14.6	43		1.0	5.6	53	193	+	+	+	+	0	1	2	+	+	0	+
17	13.5	43		1.0	4.8	73	293	+	+	+	+	0	½	2	0	+	0	+
18	12.1	35		0.8	7.7	39	140	0	+	0	0	0	1	2	0	+	0	+

* Normal absorption test values are listed. Roentgen and biopsy findings are graded on a 3+ system as discussed in "Methods."



FIG. 2. First roentgenogram of a small bowel series done on patient 2. The interpretation of all the roentgenograms of the series was severe flocculation, moderate loss of folds and segmentation, minimal dilatation and no puddling. This roentgenogram demonstrates the flocculation and loss of folds.



FIG. 3. Thirty minute roentgenogram of a small bowel series done on patient 3. The interpretation of all roentgenograms was severe dilatation and loss of folds (as demonstrated above), minimal puddling and segmentation, and no flocculation.

B. TREATED PATIENTS (NUMBERS 13-18 IN TABLE I)

Patient 13 was treated with folic acid for five years. Patient 15 was treated with B₁₂ for eight years. Patients 14, 16, 17 and 18 were treated with B₁₂ plus folic acid for eight, seven, two and two years, respectively. (Evaluation of therapy in a larger series is to be published.¹⁸)

All treated patients had normal hemo-grams. Figure 1 shows the per cent and degree of abnormal absorption tests. Nylose excretion was minimally abnormal in all



FIG. 4. Fifteen minute roentgenogram of the small bowel series done on patient 4. The interpretation of the series was severe puddling, moderate loss of folds and segmentation, minimal flocculation and no significant dilatation. This roentgenogram demonstrates the severe puddling of barium.

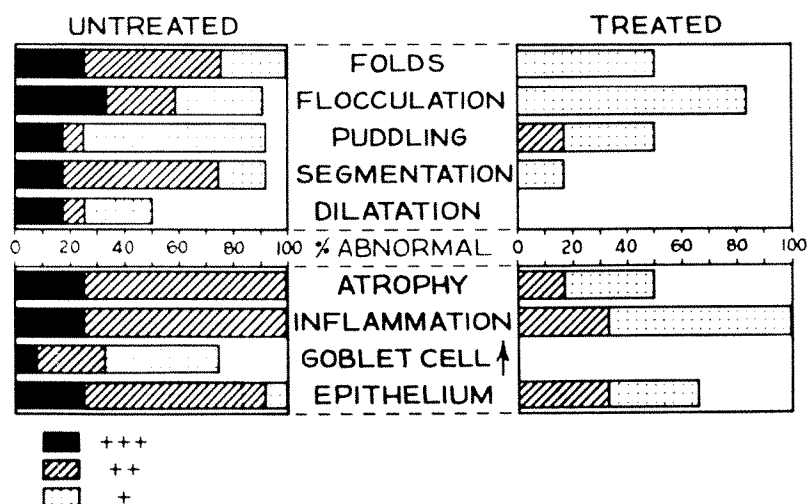


FIG. 5. Comparison of total per cent and degree of abnormality observed on biopsy and roentgen series in untreated and treated patients with tropical sprue, graded on a 3+ basis as described in "Methods."

except one patient who had a moderate defect. Steatorrhea was present in 4 and absent in 2. Carotene and vitamin A levels were normal in half of the patients.

Roentgenograms were only minimally abnormal in this group. Those of patients 13 and 18 (Fig. 9) were essentially normal. Minimal flocculation was the only persistent finding (Fig. 1) in the treated patients. The mean transit time was one hour and forty-five minutes and the mean gastric emptying two hours and forty-five minutes.

Two patients showed moderate, and one mild, atrophy on biopsy specimens (Fig. 5). Three exhibited normal villi. None had an increase in goblet cells. Epithelial changes were present in 4. Chronic moderate, or

minimal inflammation was the most persistent finding and evident on all specimens. Figure 10 is representative of the minimal changes noted in the treated group.

C. CORRELATION OF ROENTGEN INTERPRETATION AND ABSORPTION TESTS

The degree and total per cent of abnormal roentgen and biochemical absorption test findings are compared in Figure 1. In the untreated group, where roentgenographic abnormalities were most prevalent, the biochemical tests were all abnormal. In the treated group, where roentgenograms were only slightly abnormal, the absorption tests were only minimally abnormal.

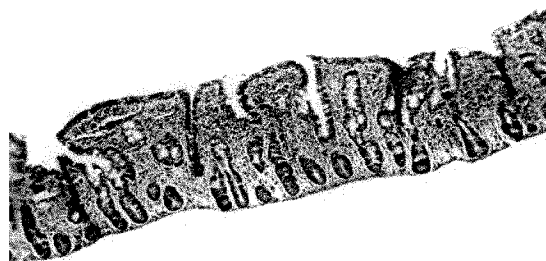


FIG. 6. Photomicrograph (X58) of a small bowel biopsy of patient 7. Note the loss of villi and increase in inflammatory cells in the lamina propria.



FIG. 7. Photomicrograph (X100) of a small bowel biopsy of patient 4. Note the loss of villi, increased stromal inflammation, and increase in the number of goblet cells.

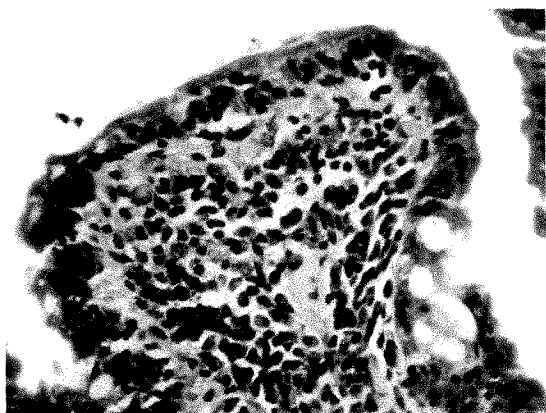


FIG. 8. High power ($\times 384$) photomicrograph of the small bowel biopsy of patient 7. Note the irregular and bizarre arrangement of the nuclei of the epithelium. The increase in round cells infiltration of the epithelium, as well as the lamina, can also be seen.

No correlation was evident between any one roentgenographic abnormality and any one absorptive test. This was due to



FIG. 9. Thirty minute roentgenogram of the roentgen series done on patient 18. This patient had been treated. Note the normal appearance of the jejunum. Only minimal flocculation was observed.

the great variations in each individual's roentgenograms (Fig. 1, 2 and 3). However, every patient who demonstrated a severely abnormal small bowel pattern had severely abnormal absorption findings (Table I).

D. CORRELATION OF ROENTGEN INTERPRETATION AND HISTOPATHOLOGIC FINDINGS

The degree and total per cent of abnormal roentgen findings are compared to the biopsy results in Figure 5. In the untreated patients, where roentgen findings were most abnormal, the biopsy revealed severe atrophy (Fig. 6 and 7), increased goblet cell proliferation (Fig. 7), inflammation (Fig. 6, 7 and 8) and abnormal epithelium (Fig. 8). In treated patients flocculation of barium and minimal chronic inflammation persisted. Otherwise, the severe abnormalities noted in the untreated group were absent both on roentgen and on histologic examination.

E. COMPARISON OF TREATED AND UNTREATED PATIENTS

The difference in findings between treated and untreated patients is demonstrated in Figures 1 and 5. The roentgenograms, biochemical tests and biopsy examinations showed that the treated patients had fewer abnormal findings and of lesser degree. The mean transit time was longer in untreated patients, but gastric emptying was more rapid.



FIG. 10. Photomicrograph ($\times 100$) of the biopsy on treated patient 15. Only a minimal increase in round cells can be observed.

DISCUSSION

Since Mackie¹¹ in 1933 and Snell and Camp¹² in 1934 first noted the roentgen appearance of the small bowel in malabsorption syndromes, the interpretation of abnormal findings has remained a point of debate. The demonstration of flocculation, puddling, and segmentation of barium has been attributed to increased mucus production,⁴ increased intestinal fatty acid,⁴ and disturbed motility.⁸ Golden,⁹ Marshak *et al.*¹² Ettinger,⁸ and Frazer *et al.*⁴ have reviewed and investigated the possible causes of the *in vivo* abnormalities in great detail. However, correlation of roentgen findings with histologic *in vivo* changes was not possible until the small bowel biopsy was established. Butterworth and Perez-Santiago,¹ Shiner and Doniach,²⁰ Rubin, *et al.*¹⁵ and others documented the histologic abnormalities observed in malabsorption syndromes. From their work it is apparent that there is a definite anatomic, as well as, biochemical defect in the small bowel. Degrees of mucosal atrophy and inflammation are consistent findings in tropical sprue,¹ celiac disease,^{15,16} and other malabsorption syndromes.²⁰

Gardner⁶ carefully correlated the small bowel roentgen abnormalities in military sprue with the clinical and chemical picture, both before and after therapy. To our knowledge this is the first study that has gone further, correlating the anatomic picture as well. We have demonstrated a relationship between small bowel roentgen studies, biochemical tests, and histologic abnormalities in tropical sprue. When the roentgenographic examination is most abnormal, the biochemical absorptive tests and the anatomic changes are most severe. When roentgen findings are only minimal, the biochemical and histologic changes are only slightly altered.

We were unable to correlate a particular roentgenographic change with a particular anatomic change; however, it was noted that in the group with marked abnormalities there was a goblet cell increase. The persistence of mild chronic round cell

infiltration in the mucosa in association with slight roentgenographic changes, primarily flocculation of barium, bears further evaluation.

Abnormal small bowel roentgen studies have been reported in emotional⁵ and neurologic¹⁰ disorders. Because of this there has been a tendency to attribute some of the roentgen changes to "functional" disease. Using the small bowel biopsy technique, we have noted changes in a variety of diseases, for example, myxedema.¹⁹ Persistent roentgenographic findings of flocculation, puddling and segmentation, as well as dilatation, certainly warrant further investigation. Neurologic or motility disturbances of the small bowel may reflect a true anatomic abnormality that should not be overlooked.

SUMMARY

Small bowel roentgenographic series, absorption tests, and small bowel biopsy specimens were studied in 18 patients with tropical sprue. Twelve cases were untreated and 6 were treated.

An excellent correlation was observed in the 3 parameters of testing. In untreated patients, where biopsy specimens and absorption tests were most abnormal, the small bowel roentgen examination was most abnormal. In treated patients where the biopsy and absorption tests were only minimally abnormal, the roentgen series was only slightly abnormal.

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FURTHER ROENTGEN OBSERVATIONS OF THE SMALL INTESTINE IN WHIPPLE'S DISEASE

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ALTHOUGH the definitive diagnosis in Whipple's disease depends largely on the laboratory data and histologic appearance of the small intestinal mucosa secured by capsule biopsy^{5,7,8} or laparotomy, considerable information can be obtained from roentgen examination of the small intestine. Since the original report in 1907 by Whipple⁹ of a generalized disease manifested primarily by polyarthritis, diarrhea, and intestinal malabsorption, the radiologic literature has contained few references to the roentgen appearance of the small bowel in this enigmatic malady. Recently, interest in this aspect of the subject has been stimulated by two reports^{3,4} which have pointed out similar features in a total of 6 patients, suggesting that a semi-diagnostic roentgen pattern may very well be present in these cases. The purpose of this communication is to present additional information corroborating this opinion and to contribute 2 authenticated cases of Whipple's disease to the currently expanding literature on this topic. Correlation of the roentgen findings with the gross and pathologic changes will also be attempted.

REPORT OF CASES

CASE I. A forty-six year old white male presented with a ten year history of intermittent migratory polyarthritis. Two years prior to admission diarrhea began, characterized by loose, greasy, foul smelling stools. A slow erosion of strength and weight loss coincided with this change of bowel habit and continued despite an excellent appetite. He lost forty pounds in weight in two years. Physical examination revealed an emaciated middle-aged male who exhibited scattered ecchymoses and pigmentation of the hands and exposed portions of the body. The abdomen was protuberant and questionably ascitic. There was bilateral pretibial and ankle edema. Significant labora-

tory data included a marked microcytic, hypochromic anemia, hypocalcemia, increased fecal fat, flat vitamin A tolerance test, and a low oral glucose tolerance test. The hospital course was gradually downhill despite aggressive dietary and supplementary therapy including ACTH, and he expired on the thirty-first hospital day.

Postmortem study revealed a dilated and thickened duodenum, jejunum and proximal ileum. The serosal surface was edematous and a cloudy gray discoloration extended from it into a thickened mesentery. Histologically, the villous folds were prominent, elongated, and densely infiltrated with PAS positive macrophages containing an abundant granular cytoplasm. These lay primarily within the lamina propria. Similar collections of macrophages were present in the edematous submucosa. Diffuse PAS positive macrophage infiltration was also noted in the heart valves, heart muscle, pancreas, skin, and mesenteric and thoracic lymph nodes.⁶

CASE II. A sixty-seven year old white male presented an unusually short period of symptoms, a three month history of diarrhea consisting of four to five semi-solid, foul smelling stools daily. This was associated with painful knees, anorexia, lassitude and a 50 pound weight loss. The physical examination showed a wasted, chronically ill elderly male who demonstrated confluent ecchymoses on the skin of the forearms and pigmentation of the skin of the lower legs. The abdomen was moderately distended. Laboratory studies were limited due to the patient's recalcitrant attitude but pertinent data revealed a hypochromic, microcytic anemia, hypocalcemia, hyproproteinemia, elevated sedimentation rate and high fecal fat determinations. Despite supportive and dietary measures, the diarrhea continued unabated. His general course was downhill. The day before death the temperature spiked to 104° F., he had a severe, shaking chill, became unresponsive, and died within thirty-six hours.

Autopsy revealed the entire small intestine to be thickened. The jejunum was dilated and



FIG. 1. Case I. A 15 minute roentgenogram showing the marked coarsening of the mucosal folds throughout the jejunum associated with moderate dilatation of the loops.

on cut section the villi were very prominent. Moderately enlarged mesenteric and peri-aortic lymph nodes were present. The microscopic examination of the jejunum disclosed the mucosa to be choked with numerous mononuclear cells giving a positive PAS stain. These cells were found chiefly in the lamina propria of the mucosa. There was no evidence of systemic involvement in contrast to that noted in Case I.

ROENTGEN AND PATHOLOGIC DISCUSSION

The most striking abnormality from a roentgen standpoint was the marked coarsening and prominence of the mucosal folds in the duodenum and jejunum, particularly in the proximal and mid-jejunal loops (Fig. 1, 2 and 3). In Case I this finding was unchanged on two examinations performed two weeks apart. It was this mucosal pattern, consistently observed in

all the cases of Martel and Hodges,³ and Scharzki,⁴ which formed the nucleus for their reports and which is corroborated as a constant finding by the 2 cases mentioned here.

In association with the marked thickening of the mucosal folds was a mild degree of dilatation in both cases. This is in contradistinction to the frequently noted marked dilatation in the malabsorption cases due to sprue.¹ It is apparently not a constant finding, however, since it was observed in only 1 of 3 cases reported in each of the articles mentioned above.

Segmentation was present in some of the distal ileal loops in Case II (Fig. 4), but this finding was entirely lacking in Case I. An explanation for its absence in Case I was the rapid transit time which amounted to between twenty and thirty minutes. In



FIG. 2. Case I. A 15 minute roentgenogram taken two weeks after Figure 1 showing a similar "accordion" appearance due to the extremely prominent mucosal folds.

FIG. 4. Case II. A 30 minute roentgenogram showing segmentation in some of the ileal loops.



Case II the transit time was within the accepted range of normal. It is thus possible to confirm the impression of other observers³ that hypomotility is not necessarily a universal finding in all malabsorptive states.

The roentgen appearance and the gross and microscopic findings reveal a close degree of correlation. A photograph of the mesentery and opened jejunum from Case II (Fig. 5) shows the increased thickness of the bowel wall and the very prominent



FIG. 3. Case II. A roentgenogram showing the very prominent mucosal folds, similar to those of Case I, in the proximal jejunal loops.



FIG. 5. Case II. Photograph of a portion of mesentery and opened jejunum showing the gross mucosal changes as well as the thickened bowel wall and mesentery.

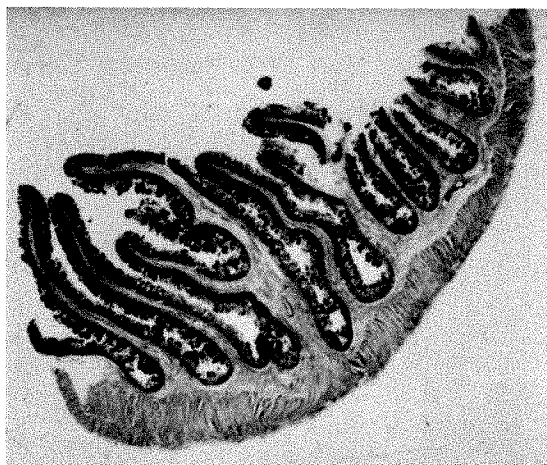


FIG. 6. Case II. Microscopic section from the jejunum (magnification $4\times$) showing the elongated villi and the thickness of the bowel wall.

folds. Figure 6 is a low power study of a section of jejunum, also from Case II, showing the elongated villi with the cavernous crypts between them. One can easily visualize the barium caught between these projections, resulting in the barium pattern shown in Figures 1, 2 and 3. The explanation for these villous and submucosal changes need not be detailed here except to state that they are due to infiltration of the lamina propria and submucosa by PAS positive macrophages.²

SUMMARY

Two cases of Whipple's disease, authenticated by postmortem study, are added to the growing number reported in recent years. The clinical and pathologic features were not unique, but the roentgen appearance of the small intestine was markedly abnormal, the principal feature being the severe thickening of the mucosal folds in the proximal small bowel loops. This pattern correlated well with that described in 6

patients recently cited in other reports. It is proposed that when a small bowel change of this type and magnitude is encountered roentgenologically, the diagnosis of Whipple's disease can be seriously considered until biopsy proof is obtained.

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The author expresses his sincere appreciation for the cooperation of F. Wells Brason, M.D., Chairman of the Department of Pathology.

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COILING OF THE LONG TUBE IN THE SMALL INTESTINE

A SIGN OF INTESTINAL OBSTRUCTION

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IN THE event that a partial or incomplete small bowel obstruction is suspected clinically, coiling of the long tube in the small intestine should be regarded as absolute evidence of obstruction, even though detailed roentgenographic studies of the abdomen in various positions or contrast studies of the small bowel are regarded as normal or inconclusive.

Coiling of the long tube is a fortuitous occurrence which allows the radiologist to accurately localize the site of small bowel obstruction and to infer, in some instances, the diameter of the dilated small bowel from the size or diameter of the bolus of coiled tubing.

When dilatation of the small bowel proximal to an obstruction is present, coiling of the long tube on itself may occur. The mechanism of coiling is dependent upon the following:

1. As the leading end of the long tube reaches the point of obstruction, further progress is prevented.

2. Continued peristaltic activity carries additional tubing into the area of obstruction—this forces the leading end of the tube to turn backwards upon itself.

3. As more tubing enters the area of obstruction, coiling of the tube commences, and may continue until the dilated intestinal lumen is filled with the coiled tubing.

If coiling of the long tube is present, a small bowel enema administered through the long tube is recommended. However, there is the possibility of confusing or seemingly normal findings in some instances since, in our experience, the obstruction may be incomplete and barium, especially when introduced through the long tube, may pass very rapidly beyond the point of obstruction.

REPORT OF A CASE

CASE 1. A.F., a thirty-nine year old white male, was admitted on November 13, 1953 with a chief complaint of upper abdominal pain. This patient had been treated by his family physician for several years for duodenal ulcer with symptoms of postprandial epigastric pain consisting mostly of a burning sensation, unrelieved by food, and becoming continuous after 5:00 P.M. The epigastric pain usually began about one to two hours after each meal and lasted from one to three hours. During the previous week the patient vomited several times and stated that he had lost 10 pounds during the last two months. There was also a history of chronic constipation. This patient had previous hospital admissions on September 25, 1953 and October 16, 1953 with similar complaints. During the hospital admission of October 16, 1953, roentgenograms revealed a markedly irritable and deformed duodenal bulb secondary to duodenal ulcer. Since the patient improved clinically during this admission, he was discharged.

Scout roentgenogram of the abdomen on November 2, 1953, demonstrated considerable scattering of gas throughout the small and large bowel, being consistent with a partial or incomplete obstruction although localization was not possible on these studies.

Subsequently a long tube was passed and consecutive studies on November 2, 3, 4 and 5 disclosed progress of the tube into the pelvic area with the tube coiling upon itself in the central portion of the pelvic cavity (Fig. 1, A and B). These findings were interpreted as a probable obstruction, incomplete or partial in type with dilatation of the small bowel proximal to the obstruction, and coiling of the long tube in the dilated small bowel.

On November 5, 1953, a barium meal was administered by means of a long tube and the roentgenogram (Fig. 2A) revealed dilatation of the lumen of the small bowel which contained the dilated coils of the long tube. It was estimated that the point of obstruction was in the

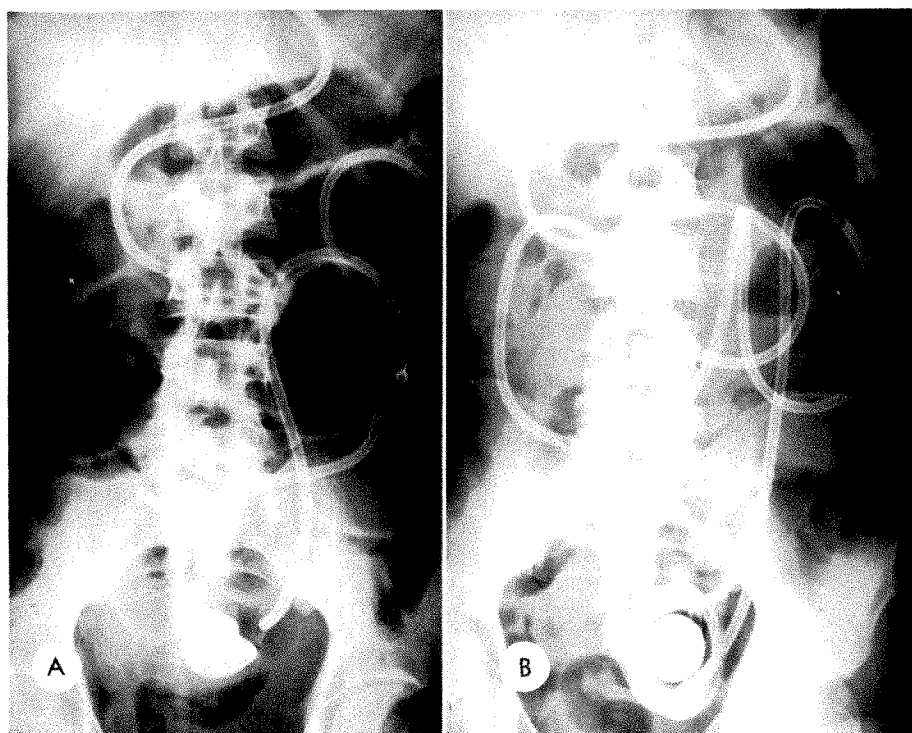


FIG. 1. (A) Anteroposterior roentgenogram of the abdomen made on November 2, 1953. Note the orientation of the long tube with the mercury portion of the tube in the pelvic cavity. Note also the scattering of gas throughout the small and large bowel. (B) Roentgenogram of the abdomen made on November 3, 1953. Studies on November 4 and 5 showed an identical orientation of the coiled tubing.

ileum and that the diameter of the small bowel at the site of obstruction measured approximately 8.5 cm. There was a delay in passage of the barium into the colon (Fig. 2B); however, at twenty-four hours there was complete emptying of the small bowel with the barium concentrating in the large bowel at this time.

Surgery was performed on November 16, 1953. The abdomen was opened through a right rectus incision. A small quantity of clear fluid was present in the peritoneal cavity. The Cantor tube was located in the proximal portion of the ileum deep in the pelvic cavity, being coiled upon itself. It was not possible to unloop this long tube. The bowel containing the coiled tubing was considerably dilated with dilatation extending proximally. An area of constriction was seen just distal to the area of coiled tubing. The mesentery of the small bowel had many white plaques of scar tissue and there were enlarged mesenteric lymph nodes. The pathologic segment of the ileum was resected and an end-to-end anastomosis was performed. A Witzel tube was inserted

about 8 inches from the anastomosis in the proximal loop and was brought out through a stab wound in the abdomen for drainage and deflation of the bowel. The abdominal wound was closed.

The pathologist reported a 7 cm. dilatation of the small bowel proximal to the constricted segment with the caliber of the small bowel decreasing proximally. In the microscopic report it was stated that the lining epithelium of the small bowel was missing in places. There was infiltration of the intestine with lymphocytes and plasma cells as well as a large number of eosinophils and polymorphonuclear leukocytes. The final diagnosis was marked acute ileitis with ulceration.

The postoperative course was uneventful and this patient was discharged on November 27, 1953.

SUMMARY

Coiling of the long tube in the small intestine indicates the presence of intestinal obstruction. Coiling permits a localization

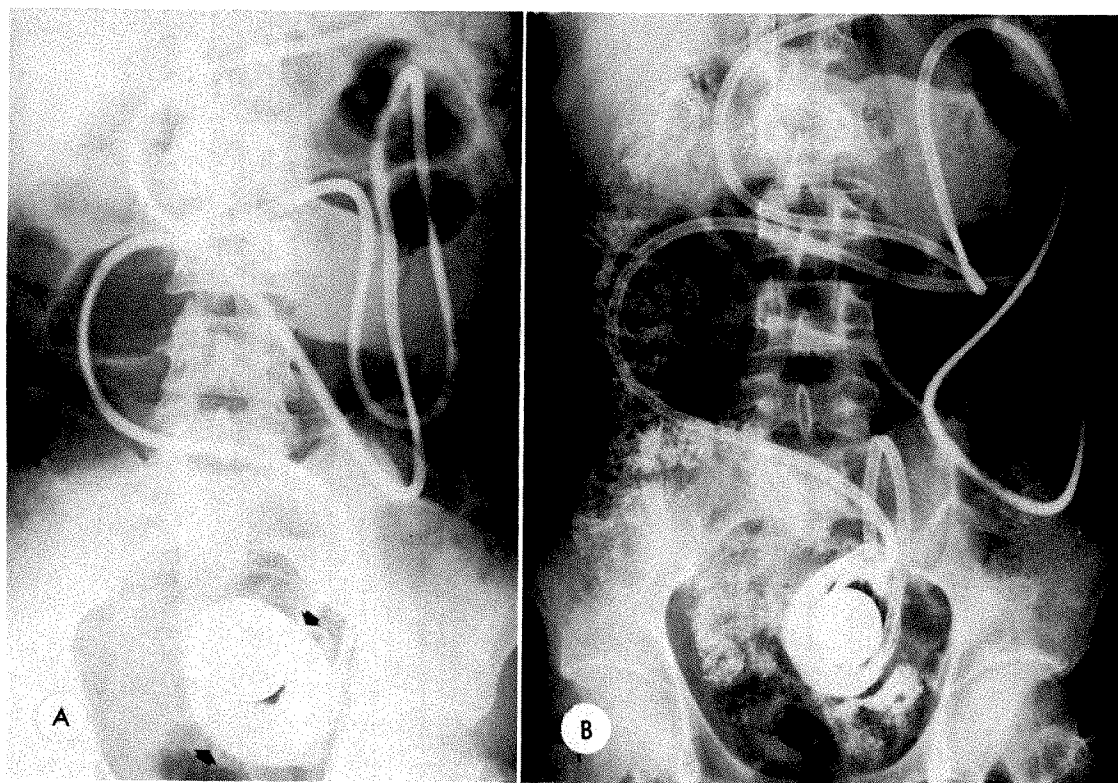


FIG. 2. (A) Roentgenogram following barium meal administration through a long tube. Note the dilatation (approximately 8.5 cm. in diameter) of the small bowel which contains the dilated tubing. (B) Six hour roentgenogram demonstrates barium scattered throughout the distal small bowel and right colon. A twenty-four hour roentgenogram demonstrated all of the barium to be present in the large bowel.

of the site of obstruction and, also, allows one to infer the degree of dilatation of the small bowel proximal to the obstruction.

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AN EVALUATION OF RADIOPAQUE SUBSTANCES FOR INTESTINAL DECOMPRESSION TUBES

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IN THE development of intestinal decompression tubes, it was apparent that a high degree of radiodensity was desirable. This was necessary to permit the radiologist, who elects fluoroscopy in positioning the tube, to know exactly where it was at all times. The more radiopaque the intestinal decompression tube, the easier it is for the fluoroscopist to see it and note coiling, kinks and angulation. Since all the tubes formerly were made of ordinary rubber with a carbon atom as the basic element, lead compounds were used to render the tubes radiopaque. There was a limit to the amount of lead compound one could use and still keep the tubes soft and light. Practically, an excellent degree of radiodensity was obtained in these rubber tubes (Fig. 1). Decreasing the amount of lead compound in the tube wall resulted in a decrease in the radiodensity (Fig. 2). This made it more difficult for the fluoroscopist to see.

With the introduction of the silicone rubber tube,^{1,2} it seemed desirable to re-evaluate the various substances that might be used in the silicone rubber to create the proper degree of radiodensity. The various stages in the development of the final acceptable silicone rubber intestinal decompression tube and the compounds tested are of interest.

The original silicone rubber intestinal decompression tube was relatively transparent roentgenographically (Fig. 3). A faint shadow was shown upon the roentgenogram because of the lack of radiodensity of the silastic rubber used to make these tubes.

It was decided to try bismuth subcarbonate as a contrast medium in the silicone rubber intestinal decompression tubes. This was done and the tubes tested clinically. It was noted that these tubes, although

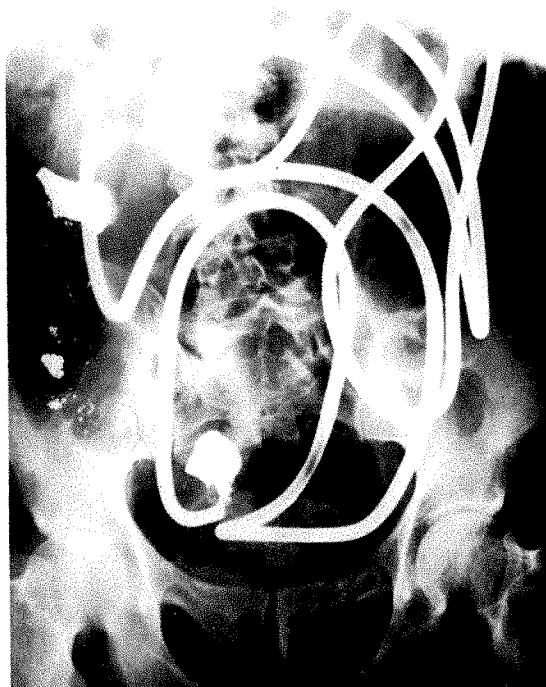


FIG. 1. Note high degree of radiodensity in lead impregnated tube.

visible roentgenographically, lacked the density so outstanding in the lead impregnated tubes (Fig. 4). Fluoroscopically, they were somewhat difficult to see because of a lack of radiodensity.

A 10 per cent barium sulfate was then selected for use as a radiopaque medium. The silastic rubber intestinal decompression tubes were impregnated with this. The results were highly gratifying. The tube that resulted was light in weight, highly elastic and resilient, with great tensile strength, and yet it was strongly radiopaque roentgenographically as well as fluoroscopically (Fig. 5). The suspension of barium sulfate is nontoxic and remains unchanged after repeated autoclaving. The tube may be stored for long periods of time without deterioration.

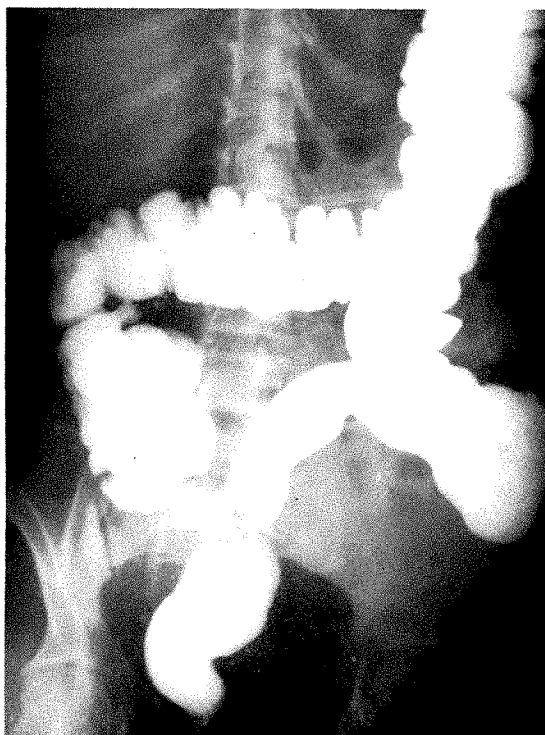


FIG. 2. Note poor radiodensity as result of decrease in concentration of contrast medium in wall of tube.

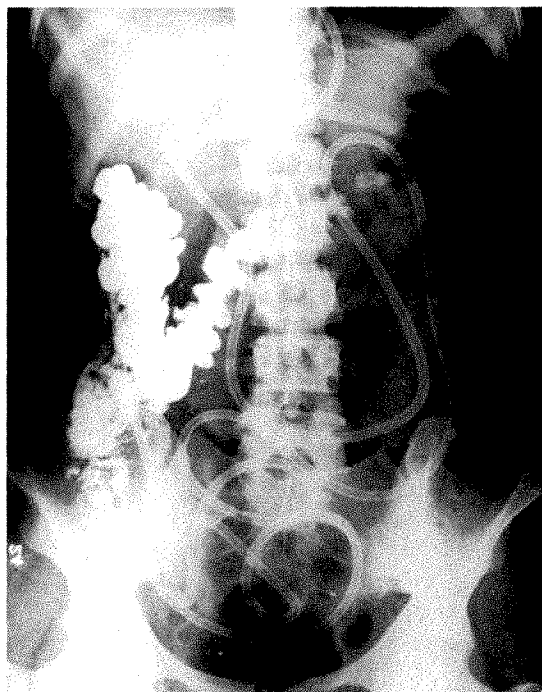


FIG. 4. Silastic rubber tube impregnated with bismuth subcarbonate.

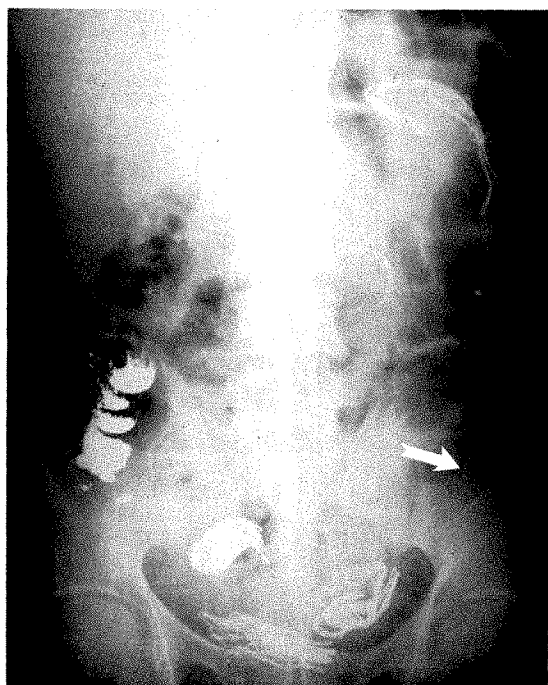


FIG. 3. Silastic rubber tube without contrast medium in its wall. Note absence of radiodensity.

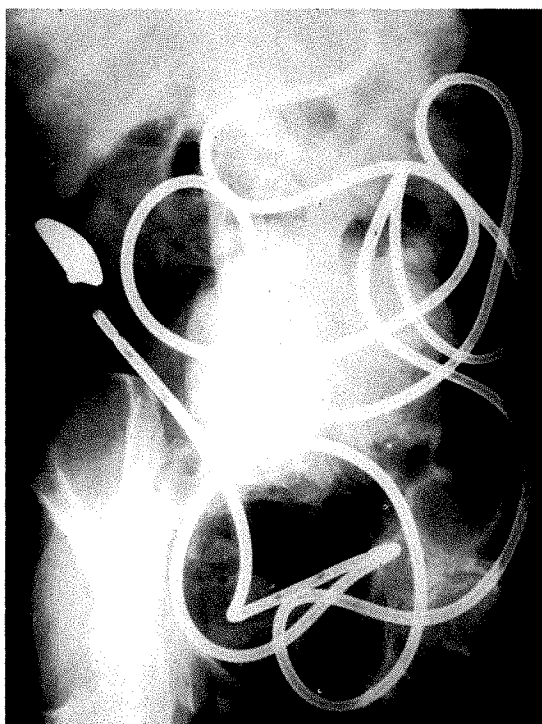


FIG. 5. Silastic rubber tube impregnated with 10 per cent suspension of barium sulfate. Note excellent radiodensity. Even the holes in the wall of the tube visualize.

CONCLUSIONS

Testing various substances for use in the silastic rubber intestinal decompression tube, it was found that a 10 per cent suspension of barium sulfate resulted in an instrument with a high degree of radiodensity. This made it excellent for use as an intestinal decompression tube especially when fluoroscopic intubation is required.

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CALCIFIED GASTRIC LEIOMYOMA*

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THE clinical and pathologic features of leiomyoma of the gastrointestinal tract, and more specifically of the stomach, have been adequately described. The roentgenologic manifestations are frequently sufficiently characteristic for the diagnosis to be made by conventional gastrointestinal study.

The histologic appearance of these lesions is identical with that of the common uterine fibroid even to the presence of microscopic calcifications.⁵ Gross calcification which is frequently demonstrable roentgenographically in the uterine tumor is indeed rare in gastric leiomyoma. Palmer,⁶ in his exhaustive review of benign stomach tumors, mentions only 2 case reports of gastric leiomyomas containing roentgenographically demonstrable calcifications and a survey of the more recent literature has revealed 4 additional cases.^{1,2,3,7} The purpose of this communication is to record another case.

REPORT OF A CASE

A sixty-one year old white female was admitted to the University Hospitals for the first time on February 3, 1960 with the chief complaint of dizziness associated with vague abdominal discomfort of approximately four weeks' duration. She considered herself in good health until the onset of the present distress. She disclaimed any gastrointestinal symptoms.

The patient consulted her local physician for the present complaint and was hospitalized. A gastrointestinal study at that time revealed a large tumor containing mottled calcification in the fundus of the stomach. The radiologist felt that this represented a leiomyoma and she was transferred to the University Hospitals for surgical treatment.

Physical examination. This revealed an obese white female in no acute distress, with normal findings and specifically no masses palpable in the abdomen.

Roentgenologic examination of the gastroin-

testinal tract. The patient swallowed the barium without difficulty and 2 small diverticula of the upper third of the esophagus were visualized. There was a large mass in the cardia which surrounded the esophageal orifice. Alteration of the mucosal pattern was noted in at least one area. Irregularity of the surface was seen which was believed to represent an ulcer crater. Mottled calcification was present throughout the mass (Fig. 1, *A* and *B*). Elsewhere the stomach and duodenum were normal. Roentgenologically, it was felt that a large calcium containing mass arose from the wall of the stomach, the surface of which appeared to be ulcerated in at least one area. The diagnosis of leiomyoma was favored. In addition, there were 2 diverticula of the esophagus.

Operative findings (Eugene Weston, M.D.). The patient was explored under general anesthesia through a thoraco-abdominal incision and a large tumor confined to the cardia was found. The smooth mass measured approximately 8 by 6 cm. and surrounded the entire cardia and lower esophagus like a doughnut. The stomach was mobile and a resection of the mass was accomplished with removal of a small portion of the lower esophagus. An esophagogastrostomy was performed and the patient recovered satisfactorily.

Pathologic findings (Walter Jaeschke, M.D.). Grossly, the specimen consisted of about 2 cm. of esophagus and a portion of cardia and fundus of the stomach measuring 7 cm. along the greater curvature. Wrapped around the cardioesophageal junction was a tumor mass shaped like half of a doughnut 15 cm. about the periphery. The cross diameter of the mass was 3 cm. On section the tumor was white, moderately firm, and suggested a whorled pattern. On the mucosal surface of the stomach, 3 cm. below the cardioesophageal junction, in the area of the tumor, there was an evagination of the mucosa in diverticulum-like fashion, 1 cm. in diameter and 1 cm. deep.

Microscopic examination of the esophagus showed unremarkable squamous epithelium. The tumor was composed of whorled masses of smooth muscle cells. The nuclei were small and

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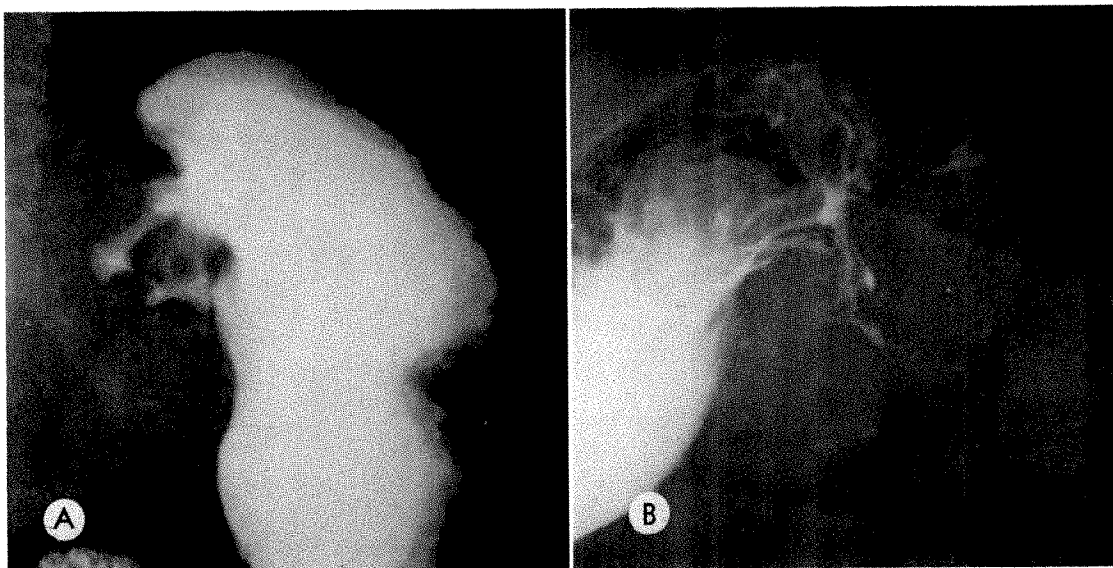


FIG. 1. (A and B) Gastrointestinal study shows that the lesion is well outlined by its projection into the barium as well as by the mottled calcification which is contained throughout. The evagination of the mucosa into the mass which was revealed pathologically is well demonstrated.

spindle shaped. Mitotic figures were not seen.

Diagnosis. Leiomyoma.

DISCUSSION

The presence of mottled calcification in a gastric leiomyoma is of significance in the differential diagnosis of calcification seen in the left upper quadrant of the abdomen. Even when the calcification is localized specifically to the stomach, it is not pathognomonic of leiomyoma. Several cases of mucinous adenocarcinoma of the stomach containing similar mottled calcifications have been reported. Conventional gastrointestinal study should enable one to differentiate the two lesions. The intramural location of the leiomyoma with a smooth surface and possibly isolated areas of ulceration should be readily distinguishable from an adenocarcinoma which, in general, is an intraluminal lesion with an irregular surface.

SUMMARY

A case of a gastric leiomyoma with roent-

genographically demonstrable calcifications is presented. The significance of the calcification is discussed.

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PROLAPSE OF GASTRIC MUCOSA*

REPORT OF AN UNUSUAL CASE

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THE incidence of prolapse of the gastric mucosa varies considerably in different series; however, higher figures have been reported in more recent publications.^{2,5,6,10} This reflects increasing acceptance of the condition as a clinical and pathologic entity, although some controversy still surrounds the subject.⁹ The diagnosis is based mainly on roentgenologic findings, which are almost pathognomonic,² although occasionally confusion may arise when a massive prolapse mimics a pedunculated tumor, slipping back and forth through the pyloric canal. This paper reports such a case with roentgen, surgical and pathologic findings.

REPORT OF A CASE

The patient was a thirty-eight year old white female hospitalized for acute bronchitis. For about a year she had suffered from epigastric discomfort. More recently, she was distressed by a more constant gnawing sensation and at times sharp cramping pain in the mid-epigastrium. The effect of food was variable: sometimes she felt better, other times much worse, after meals. Nervous tension and emotional upsets often exacerbated the symptoms. There had been no vomiting or bleeding from the gastrointestinal tract. Physical examination revealed slight tenderness but no rigidity or palpable mass in the mid-epigastric area. Other findings were within normal limits.

Roentgen Findings. Roentgenograms showed a large filling defect, 4-5 cm. in size, in the gastric antrum (Fig. 1A) or in the duodenal bulb (Fig. 1B) at different times during the same examination. There was no evidence of ulceration or other intrinsic abnormality. A pedunculated benign gastric polyp was reported; prolapse of gastric mucosa was considered unlikely.

Surgical Findings. At operation the stomach was found to be moderately enlarged with a

palpable mass in the antrum. After it was opened, a markedly hypertrophied, redundant, and hyperemic gastric mucosa was disclosed. This could readily slip back and forth through the pylorus. There was no ulceration or tendency to bleed. A subtotal gastrectomy and a Billroth I gastroenterostomy were performed.

Pathologic Findings. The mucosa of the pyloric antrum was markedly redundant and formed a 4 cm. bulging mass completely surrounding the wall of the stomach (Fig. 2). Section showed marked hypertrophy of the mucosa which was thrown up in large folds. The submucosa was thickened and edematous. There was mild inflammation but no evidence of ulceration.

DISCUSSION

The movements of gastrointestinal mucosa were first investigated by Forssell,³ whose findings were confirmed by the studies of Golden.⁴ According to these workers, considerable gliding movement of the gastric mucosa over the submucosa normally occurs during physiologic peristalsis; this is anatomically possible because of the loose attachment between the two layers. Golden also demonstrated that hyperperistalsis and hypertrophy of the gastric mucosa secondary to gastritis were conducive to mucosal prolapse through the pylorus. While the roentgen diagnosis of prolapse of the gastric mucosa is reliable and nearly always confirmed in patients who come to operation, consecutive autopsy study of 1,500 cases has failed to show a single instance of transpyloric prolapse.² It seems that with the cessation of peristalsis the prolapsed mucosa always slips back into the stomach, and a state of prolapse cannot be maintained after death.

The clinical symptoms are seldom clear cut and may vaguely resemble those of a

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FIG. 1. (A) Filling defect in gastric antrum, and (B) the same lesion in the duodenal bulb, during the same examination.

number of gastroduodenal diseases; namely gastritis, duodenal ulcer, gastric ulcer, and duodenitis, with which gastric mucosal prolapse is frequently associated.^{2,5,6,8,10} Bleeding and secondary anemia occur in an appreciable number of cases, whereas pyloric obstruction is rare.^{2,5,6} The etiology is not definitely known. The consensus of opinion favors the hypothesis of inflammatory hypertrophy and hypermotility of the stomach as important factors.³ Nervous tension and emotional upsets may aggravate the condition.⁵

The roentgen appearance of prolapse of the gastric mucosa varies with the degree of redundancy, the height of peristaltic activity, and the extent of protrusion. In the average case a mushroom, honey-comb, or

lobulated filling defect in the duodenal bulb and associated changes of gastric mucosal rugal pattern in the antrum and pylorus are characteristic.² When the defect is large and reducible, its differential diagnosis from a pedunculated gastric polyp and other benign lesions may become problematic.^{7,8} In the case reported here although the filling defect in the duodenal bulb (Fig. 1B) is suggestive of prolapsed gastric mucosa, its presence in the gastric antrum (Fig. 1A) compelled the consideration of a pedunculated tumor.

Most uncomplicated cases may respond favorably to medical therapy. Surgical treatment has been advocated in patients with intractable symptoms, recurrent bleeding, or pyloric obstruction.^{1,5,6,8,10} When

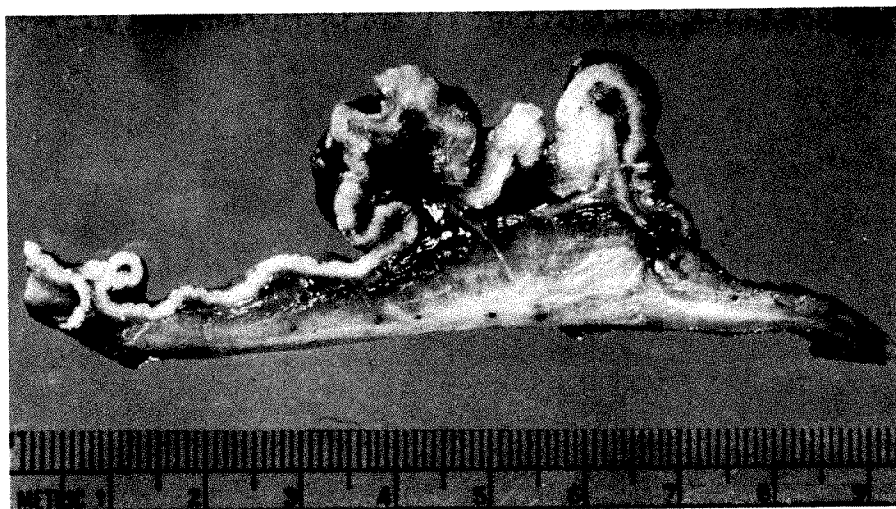


FIG. 2. Surgical specimen opened longitudinally. Note the marked hypertrophy and redundancy of the gastric mucosa thrown into large folds which pile up over pyloric muscle. The gastric antrum is on the left, the duodenal bulb on the right of the pylorus.

the diagnosis was clarified at the time of surgery, subtotal gastrectomy seemed the procedure of choice in this patient in view of the size of the lesion.

SUMMARY

An unusual case of massive prolapse of the gastric mucosa simulating pedunculated gastric polyp is reported. The surgical and pathologic findings are described.

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ACUTE HEMORRHAGIC PANCREATITIS COMPLICATED BY DUODENAL OBSTRUCTION

REPORT OF A CASE

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THE more common early and late intra-abdominal complications of acute pancreatitis are well documented.^{2,7} Among these are peritonitis, gross gastrointestinal bleeding, abscess formation, sinus tracts, fistulae and pseudocyst formation. Intestinal obstruction as a complication of acute pancreatitis is rather uncommon. A few cases of large bowel obstruction, usually occurring at the splenic flexure, have been reported.^{1,4,10} Two cases of small bowel obstruction distal to the duodenum and involving the proximal jejunum and ileum, respectively, have also been recorded.^{3,5} Duodenal obstruction is apparently an unusual complication of acute hemorrhagic pancreatitis.

REPORT OF A CASE

A twenty-nine year old Negro female was admitted to the Medical Department of Mercy Hospital on June 19, 1960 with a three day history of abdominal pain. Initially, epigastric pain began one-half hour after eating and subsided with administration of an alkali. The following day, after the patient drank approximately two quarts of beer, abdominal pain recurred and extended over the entire abdomen. The pain was accompanied by nausea and vomiting. A small amount of blood in the vomitus was noted by the patient. Pain and emesis continued until the time of admission. There was no previous history of abdominal pain, jaundice, melena or hematemesis. Past medical history was noncontributory.

Physical examination on admission revealed a well-developed, well-nourished female complaining of constant abdominal pain. The patient was afebrile and vital signs were within normal limits. No icterus was noted. The chest was clear. Abdominal examination revealed

tenderness without rebound in the midepigastrium and right upper quadrant. No masses or organs were palpable. Peristalsis was reported as being normal. Pelvic and rectal examinations demonstrated no abnormalities. The tentative clinical diagnosis at this time was a possible bleeding peptic ulcer or acute pancreatitis.

Laboratory data on admission revealed a hemoglobin of 8.3 gm. per cent and a white blood cell count of 6,350 with 77 per cent neutrophils. Urinalysis demonstrated 4+ acetone, no sugar or protein and a negative microscopic report. A blood amylase level of 111.3 units (20-40 normal) was also recorded.

A plain roentgenogram of the abdomen on admission disclosed a moderately distended stomach with a striking absence of gas in the small and large bowel suggesting a high obstruction. No free intraperitoneal air was demonstrated.

The patient was seen in surgical consultation on the evening of admission; the opinion was either acute gastritis or bleeding peptic ulcer. A regimen of intravenous fluids and potent analgesics was started.

The following day, the abdominal pain had subsided somewhat, but vomiting persisted necessitating nasogastric suction. A repeat blood amylase level was reported at 218 units and a urinary diastase level of 1,024 units (normal less than 30 units).

At this time, an emergency roentgen examination of the upper gastrointestinal tract disclosed no abnormality of the esophagus or stomach. There was a complete obstruction to the passage of barium at the distal end of the first portion of the duodenum with a smooth crescentic defect on the greater curvature of the bulb (Fig. 1). A follow-up roentgenogram taken at one and one-half hours showed no further progress of the barium. A roentgenogram at seven hours demonstrated that only a small amount of barium had passed into the

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small bowel. The roentgenologic impression was that of an extrinsic lesion causing obstruction of the duodenum, most likely pancreatic in origin.

The patient began to show some improvement the next day, being still maintained on nasogastric suction and intravenous fluids. The blood amylase level decreased to 160, and the temperature range was 99°–100°F. A repeat roentgenogram of the abdomen again showed no gas in the small bowel. However, the contrast medium from the previous day's study was noted to be entirely within the ascending colon.

During the next five days, the patient's condition gradually improved and she was started on oral liquids. On repeat blood study, hemoglobin was 6 gm. per cent and the patient was then given 1,000 cc. of whole blood. The urinary diastase level had dropped to 512 units. However, on the tenth hospital day, the patient began to vomit again and upon examination of the abdomen, a round, smooth ballotable mass was now palpable in the right upper quadrant; this was felt to be a distended gallbladder. A total bilirubin of 1.12 was reported at this time. The patient was again placed on suction and intravenous fluids.

A limited roentgenologic examination of the upper gastrointestinal tract, utilizing a water soluble contrast medium administered through the nasogastric tube, again demonstrated complete obstruction of the distal portion of the bulb and the previously noted crescentic defect on the greater curvature of the bulb was felt to have increased in size. A suggestion of a soft tissue mass approximately 11 cm. in diameter and inferior to the bulb was also noted at this time.

The patient's general condition did not improve and surgical exploration was deemed necessary for relief of the obstruction. On July 1, (twelfth hospital day) laparotomy was performed. A small amount of dark brown fluid was found in the abdominal cavity with retroperitoneal hemorrhage on the right side extending from the hepatic flexure down to the pelvis. The stomach was markedly distended with bulging of the first part of the duodenum. There was a large edematous, hemorrhagic mass in the region of the head of the pancreas extending into the transverse mesocolon with collapse of the second and third portions of the duodenum. The gallbladder was distended and

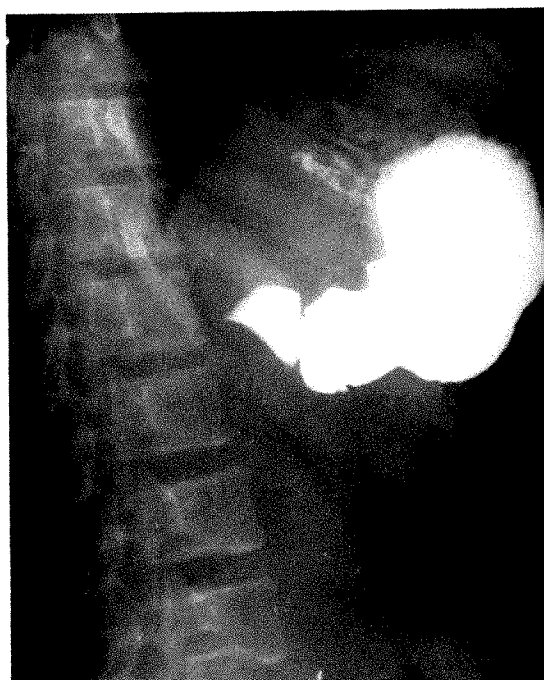


FIG. 1. Barium meal study performed the day following admission. The obstruction at the first portion of the duodenum and the crescentic defect on the greater curvature of the bulb are demonstrated.

thin-walled. A diagnosis of acute hemorrhagic pancreatitis was made and, because of the duodenal obstruction, a gastrojejunostomy was carried out.

Following surgery, the patient did well and on the fifth postoperative day was eating without difficulty. She then developed multiple sterile skin abscesses which responded to incision and drainage. Progressive improvement continued until the twenty-seventh postoperative day when she began to vomit after each meal, necessitating reinstitution of nasogastric suction. Roentgenologic re-examination of the upper gastrointestinal tract at this time demonstrated complete obstruction of the efferent loop of the gastrojejunostomy just distal to the anastomosis (Fig. 2). The duodenal bulb filled well and was normal in appearance. Extrinsic pressure on the second and third parts of the duodenum was noted. A urinary diastase level of 512 units was recorded at this time. The question of a recurrent episode of pancreatitis was raised and the patient was treated vigorously with a medical regimen including salt-free human serum albumin.

Within the next two days, the patient showed



FIG. 2. Roentgen examination of the gastrointestinal tract performed on the twenty-seventh postoperative day because of sudden onset of epigastric pain and vomiting. The demonstrated obstruction at the efferent loop and the extrinsic pressure on the distal duodenum were believed to be caused by a recurrent episode of pancreatitis.

marked improvement and continued to a full recovery. A urinary diastase level of 32 units was recorded at the time of discharge two weeks later on August 12, 1960. Three months after discharge the patient was free of abdominal pain and generally in good health.

DISCUSSION

Since surgical intervention in the acute stages of pancreatitis is undertaken only occasionally, the involvement of the duodenum in acute pancreatitis has been studied primarily from the roentgenologic viewpoint. The basic examination has been the barium meal.

Poppel⁸ has divided the roentgenologic manifestations referable to the duodenum into early functional disturbance and late structural changes. In the initial stages of the inflammatory process, there are changes

in the peristaltic activity and motility of the duodenum. Retrograde peristalsis and localized areas of spasm and segmentation may be observed. As the pathologic process continues, irritability of the duodenal loop is followed by a duodenal ileus with stasis of barium in the dependent portion of the duodenum. Concomitant with enlargement of the head of the pancreas, there is noted an upward displacement of the duodenal bulb which sometimes may be compressed, as noted in the case presented. The duodenal loop is displaced to the right and widened. Edema of the mucosa produces a coarse appearance of the mucosal pattern, particularly along the medial margin of the loop. Occasionally, a filling defect is noted in the descending portion of the duodenum corresponding to the position of an edematous papilla of Vater.⁹ If enlargement of the head of the pancreas continues to a sufficient degree, further displacement of the duodenal loop to the right may be impossible and complete obstruction of the lumen of the duodenum will take place.

In a review of the English literature, the authors have been able to find only two instances of complete duodenal obstruction in acute pancreatitis. Moore⁶ cites a case reported by Benedett of acute duodenal obstruction caused by acute pancreatitis involving an annular pancreas. The obstruction of the duodenum in this case was due to an actual constriction of the lumen by the edematous annular pancreas. The second case is that reported by Street¹¹ in which acute pancreatitis occurred following closed abdominal trauma. The roentgenographic findings in this case were similar to those in our case.

The duodenal obstruction in our case was demonstrated by a barium meal examination performed on the day following the patient's admission to the hospital. At the site of the obstruction, a smooth, crescentic defect on the greater curvature of the duodenal bulb was demonstrated on the roentgenograms. At surgery, a large edematous, hemorrhagic mass in the region of the head of the pancreas encroaching on

the first portion of the duodenum and completely collapsing the second and third portions was found. A gastroenterostomy was performed to relieve the obstruction, as was done in Street's¹¹ case.

Of particular interest in our case was the occurrence of a roentgenographically demonstrated obstruction at the enterostomy site some two weeks following surgery. This obstruction was felt to be on the basis of a recurrent episode of pancreatitis. The patient was placed on a strict medical regimen with a full recovery.

SUMMARY

A case is presented of acute hemorrhagic pancreatitis in a twenty-nine year old Negro female complicated by complete obstruction at the first part of the duodenum necessitating gastrojejunostomy for relief of the obstruction. A further interesting occurrence was what appeared to be a recurrent episode of pancreatitis causing an obstruction at the site of the gastrojejunostomy. This was relieved following intensive medical therapy.

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CHRONIC CHOLECYSTITIS

INDICATIONS FOR REVISION OF THE CLINICAL DIAGNOSIS

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AFTER some years of experience in an era of greater diagnostic accuracy for digestive disorders, it seems a proper time to review and re-evaluate the criteria used in this area of diagnosis. The tendency is great to adhere to signs and symptoms established long ago, but some of these will prove unreliable or of little value in the light of modern study.

The textbooks are more than complete with descriptions of symptoms and signs, but too often the important ones are obscured or down-graded by the many unimportant ones.

The following study was undertaken after a long period of living with such thoughts.

METHOD AND MATERIAL

For several years, patients coming to the Presbyterian Hospital for cholecystograms have been given a special examination by the author, comprising a history interview, abdominal palpation, fluoroscopy of the chest and abdomen, erect fluoroscopic spot roentgenograms of the gallbladder and the usual standard and specialized roentgen study. This experience has revealed marked discrepancies and unreliability in the classic basis of a clinical diagnosis, and has indicated a need for analysis of clinical signs and a close study of roentgen methods. Such a review has been effected by a detailed and statistical examination of 200 patients coming for cholecystography (100 "normals" and 100 rigidly confirmed cholecystitis patients).

The abnormal cholecystogram has been used as the first indication of cholecystitis, but only those patients having unquestionable gallstones or a surgical and pathologic diagnosis of cholecystitis have been placed in the abnormal group. These are

regarded as absolutely confirmed.

The normal group includes only those subjects who showed completely normal opaque contrast studies, as determined by a roentgen technique especially designed to demonstrate stones and regarded as most accurate. Patients disclosing even slight reduction of opaque material in the gallbladder (without stones) were not admitted into the normal group.

There can be some criticism of the "normal" criteria in such a study, primarily because none of these normals will have had operation to provide absolute confirmation. Their normalcy therefore rests on roentgenologic study, and such classification is only as accurate as the method. This is recognized and for years our technique has been improved and revised, and compared with clinical and pathologic data. The erect, overpenetrated, fluoroscopic spot roentgenograms have been used with what we regard as great accuracy, and have been important in disclosing minute stones that would have escaped detection by other techniques.

SYMPTOMS

A list containing 23 symptoms was presented to each patient for answer, after each had an opportunity to volunteer her own complaints. The interrogator did not know the roentgen diagnosis at this time.

Of the first 5 symptoms appearing in the abnormal group, 4 are duplicated in the first 5 of the normal group (Fig. 1).

<i>Cholecystitis</i>	<i>Order of Incidence</i>	<i>Normal Gallbladder</i>
Gas	1	Indigestion
Belching	2	Gas
Indigestion	3	Belching
Nausea	4	More comfort a.c.
Right upper quadrant pain	5	Nausea

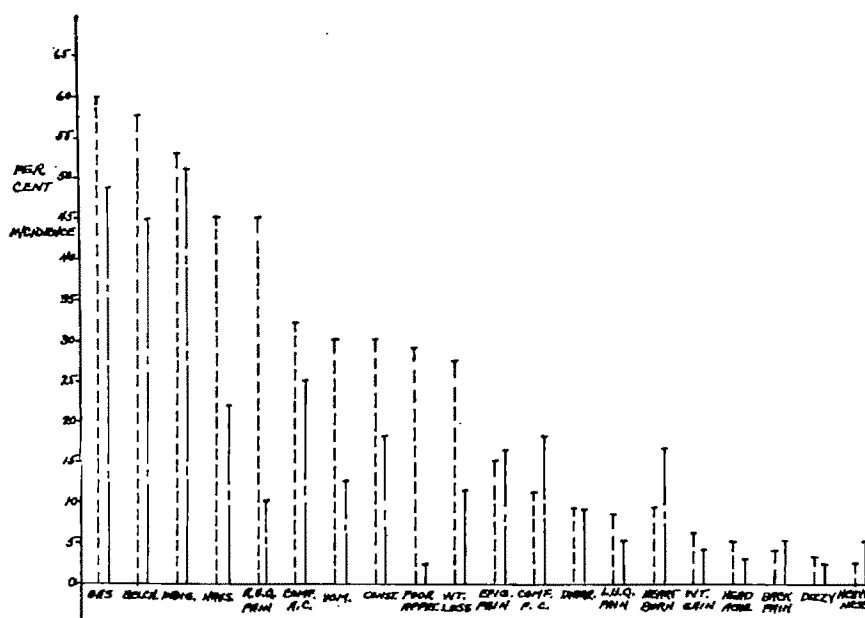


FIG. 1. Symptom incidence in cholecystitis and noncholecystitis patients (100 of each).

Key: In cholecystitis patients -----
In noncholecystitis patients —————

Right upper quadrant pain stands out as a most valuable indicator, occurring in each of 5 analyses, much more often in the cholecystitis group. Furthermore, it is less prone to occur in nonbiliary disease than any other symptom. This study has established right upper quadrant pain as the outstanding symptom in chronic cholecystitis, in keeping with the reliable objective sign of right upper quadrant tenderness and rigidity in acute or relapsing disease.

The classic symptoms of cholecystitis, occurring about equally or more in the *normal* gallbladder patients as compared to the abnormal, are: indigestion, epigastric pain, heartburn, heaviness, dizziness and back pain, with gas and belching occurring only slightly more often in the cholecystitis group. This finding relegates many of the old favorites to the category of general and nonspecific digestive tract symptoms, occurring in many ailments and creating large and numerous overlaps. Recent observations by others in this field corroborate these data.^{3,5}

Symptoms occurring much more fre-

quently in cholecystitis than in normal patients are as follows:

	Chole- cystitis		Normal Gall- bladder
1. Poor appetite	29%	14:1	2%
2. Right upper quad- rant pain	45%	4.5:1	10%
3. Weight loss	27%	2.5:1	11%
4. Vomiting	30%	2.3:1	13%
5. Nausea	45%	2:1	22%

Nausea loses some of its diagnostic value in being fifth of the complaints of normals. This leaves anorexia, right upper quadrant pain, weight loss and vomiting as the more valuable symptoms—in short, right upper quadrant pain and aversion to food. Finally, the ratio of average number of symptoms per patient in the cholecystitis and normal series is very low: cholecystitis 4.9 to normal 3.5, a ratio of 1.4.

In summary, many of the so-called classic symptoms of cholecystitis apparently belong to several digestive disturbances; the ratio of complaints offered by the cholecystitis patient to the normal biliary

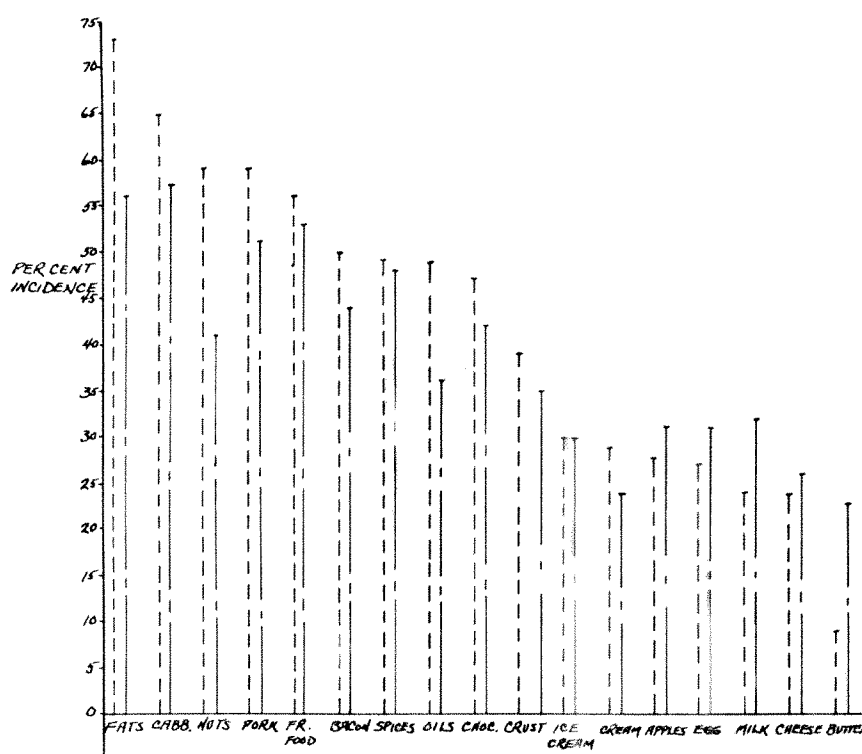


FIG. 2. Food intolerance incidence in cholecystitis and noncholecystitis patients (100 of each).

Key: In cholecystitis patients -----
In noncholecystitis patients —————

patient is less than 1.5; some symptoms— anorexia, right upper quadrant pain, weight loss, vomiting and nausea—stand out as useful diagnostic signs, the most valuable being right upper quadrant pain.

FOOD INTOLERANCE

The food history was secured by asking the patient to state tolerance with comfort or intolerance to each food of a group of 17. "Fried foods" and "fats" were used as samples, but they were the only collective terms applied and 15 other food types were used in this testing. It has been noted repeatedly that these 2 terms ("fried food" and "fats") may be the only ones used by the clinical examiner in securing a food history and that answers by the patient are correspondingly unreliable.* The inference is strong that public sentiment and propaganda are important opinion makers. By requesting separate answers for each type

of food, memory and independent thought were stimulated and, perhaps, a more valid history was produced (Fig. 2).

Of the first 6 intolerable foods, 5 are common to both groups:

<i>Cholecystitis</i>	<i>Order of Intolerance</i>	<i>Normal Gallbladder</i>
*Fats	1	Cabbage
Cabbage	2	*Fats
Nuts	3	*Fried foods
Pork	4	Pork
*Fried foods	5	Spices
Bacon	6	Bacon

Further analysis reveals the first 10 intolerables of each group to be the same. Milk products and egg were consistently at the lower end in both groups and failed to yield any worthwhile differential. Those foods intolerable to as many or more patients *without* cholecystitis than with cholecystitis were: apples, butter, cheese, ice cream, eggs, milk, and spices.

The foods revealing the largest differentials and being greater offenders to the cholecystitis patients were: fats, 73 per cent (normal 56 per cent), nuts, 59 per cent (normal 41 per cent), and oils, 49 per cent (normal 36 per cent). Such differences may aid in the diagnosis in a large series, but are of doubtful value for the individual patient.

Reviewing all the data on foods, it is highly questionable that any reliable diagnostic aid can be had in a food history; and it is obvious that many of the classic symptoms occur in other than biliary patients.

CONCLUSIONS

Personal experience in interviewing patients coming for cholecystography has revealed confusion and variability in clinical history and has shown wide discrepancies between the clinical and roentgen basis of the diagnosis of chronic cholecystitis. This has occurred in a period when the roentgen method has reached a high degree of accuracy. A statistical examination of the symptom and food history was undertaken.

Analysis indicates that many of the classic symptoms occur in patients with nonbiliary disease and probably belong to several digestive disturbances; that right upper quadrant pain, anorexia, weight loss

and vomiting appear to be useful diagnostic aids, the most reliable being right upper quadrant pain.

The study of foods shows a history of intolerance in patients with biliary and nonbiliary disorders that is quite general and impressively nondiagnostic. The differential values of fats, nuts and oils are the best indicators, but probably too small for reliability in individual diagnosis.

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PNEUMATIC COMPRESSION PADDLE (PRONE PRESSURE DEVICE) IN CHOLECYSTOGRAPHY AND CHOLEDOCHOGRAPHY

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OVERLYING intestinal shadows are the most vexatious feature with which the radiologist is concerned when performing cholecystography and/or cholelithography. To combat these troublesome shadows, preparatory enemas, cathartics, laminagraphy, and patient positioning (including decubitus, upright, Trendelenburg, and spot filming procedures) are often used. Even then, there remain instances in which overlying intestinal shadows make accurate diagnoses difficult.

Eliasoph and Marshak¹ reported on the use of a prone pressure device for displacing undesirable intestinal shadows in intravenous cholangiography in 1957. Since then, we have had a rewarding experience with this method, not only for cholelithographic demonstrations (both oral and intravenous) but also in cholecystography. It is a simple, readily available method for use in all roentgenologic offices and departments.

The advantages of a pneumatic compression paddle are many. Not only does the compression of tissues displace intestinal shadows, but it also makes for a thinner part and gives rise to a uniform gas contrast material as a background to the gallbladder and the biliary duct system. The part being studied is transfixed (so to speak) and is thereby better immobilized for finer detail. Grading of the pressure applied, by inflating or deflating the balloon, aids in the delineation of small stones in the biliary duct system and in the detection of tiny negative shadows in gallbladders, as for instance in the adenomyomatosis of this organ.

We have utilized the pneumatic compression paddle illustrated in Figure 1, *A*

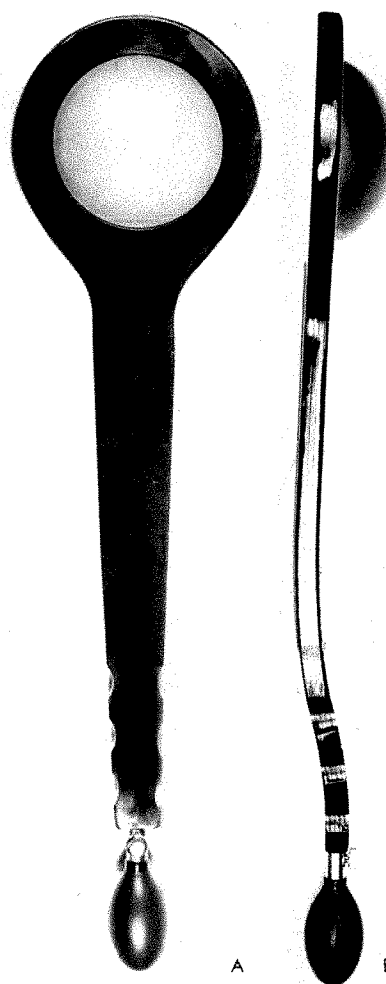


FIG. 1. Front (*A*) and profile views (*B*) of the pneumatic compression paddle with its balloon partially inflated.

and *B*.^{*} It consists of an inflatable rubber bladder set into a long offset handle with the inflation-controlling bulb at the end. A buried lead circle surrounding the bladder fluoroscopically indicates the region under

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compression. For gallbladder and choledochographic studies, the paddle is placed in position from the left side so that it is not displaced from the body by the patient's weight when inflated (Fig. 2). Often, fluoroscopy (especially image amplification) is used for exact positioning. It is important to expose the films in the same stage of respiration that centers the paddle and the part being studied. Then roentgenograms are made with varying degrees of inflation of the balloon employing either less time or less kvp. than is used in routine roentgenography dependent on the degree of balloon expansion. The paddle is left in place until the wet films are viewed. The patient can then be readjusted or rotated for further roentgenography if necessary.

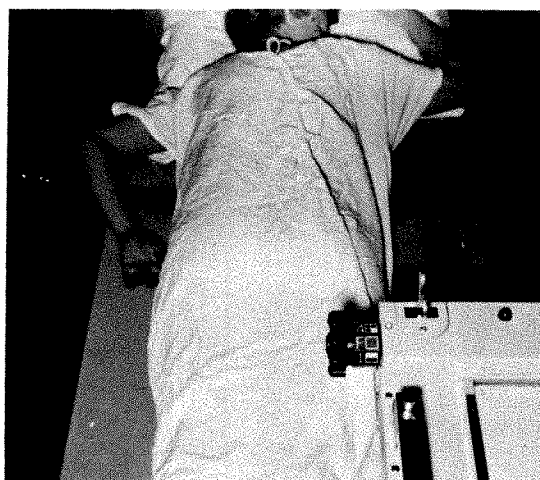


FIG. 2. Photograph showing the pneumatic compression paddle placed into position from the left side of the patient.



FIG. 3. Normal cholecystograms showing (A) intestinal shadows obscuring the opacified gallbladder and (B) removal of the overlying shadows by compression displacement.

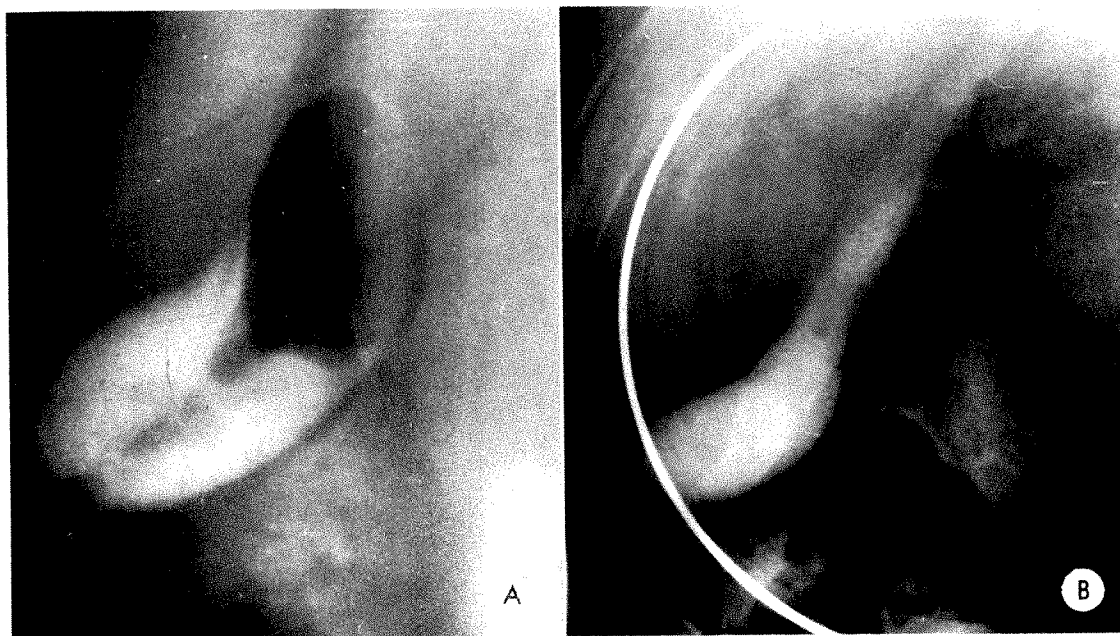


FIG. 4. Cholecystograms showing (A) the gallbladder obscured by overlying gas shadows and (B) with pneumatic graded compression, the visualization of an adherent cholesterol type stone.

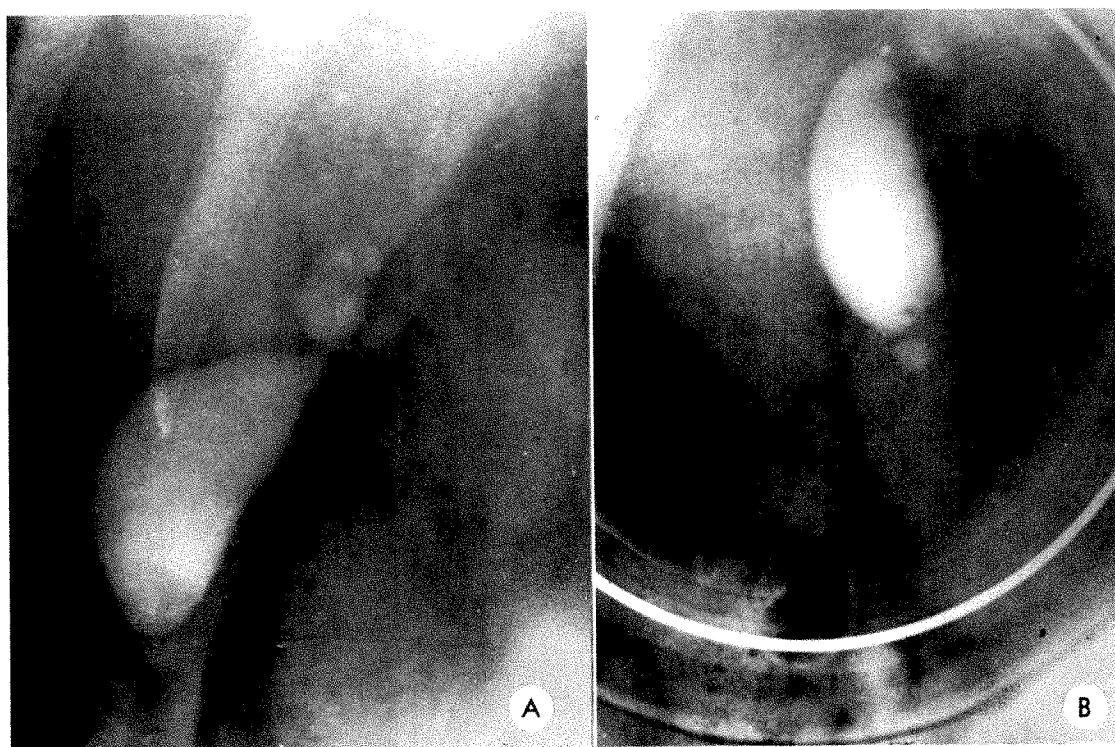


FIG. 5. Cholecystograms showing (A) the lack of visualization of an adenomyoma just proximal to a distal fundal compartment and (B) with graded compression by the pneumatic compression paddle properly positioned, the clear delineation of the adenomyoma.

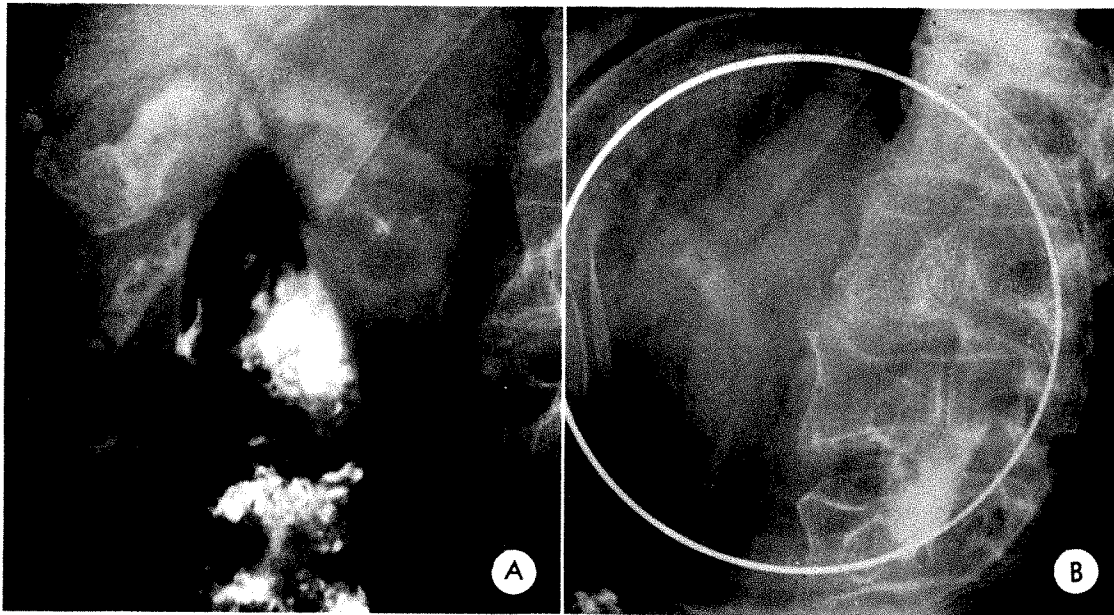


FIG. 6. Oral cholangiograms in a postcholecystectomized patient showing (*A*) a marked amount of ingested opaque material as well as gaseous shadows in the overlying intestine and (*B*) a normal common duct with all confusing intestinal shadows displaced by the pneumatic compression paddle.

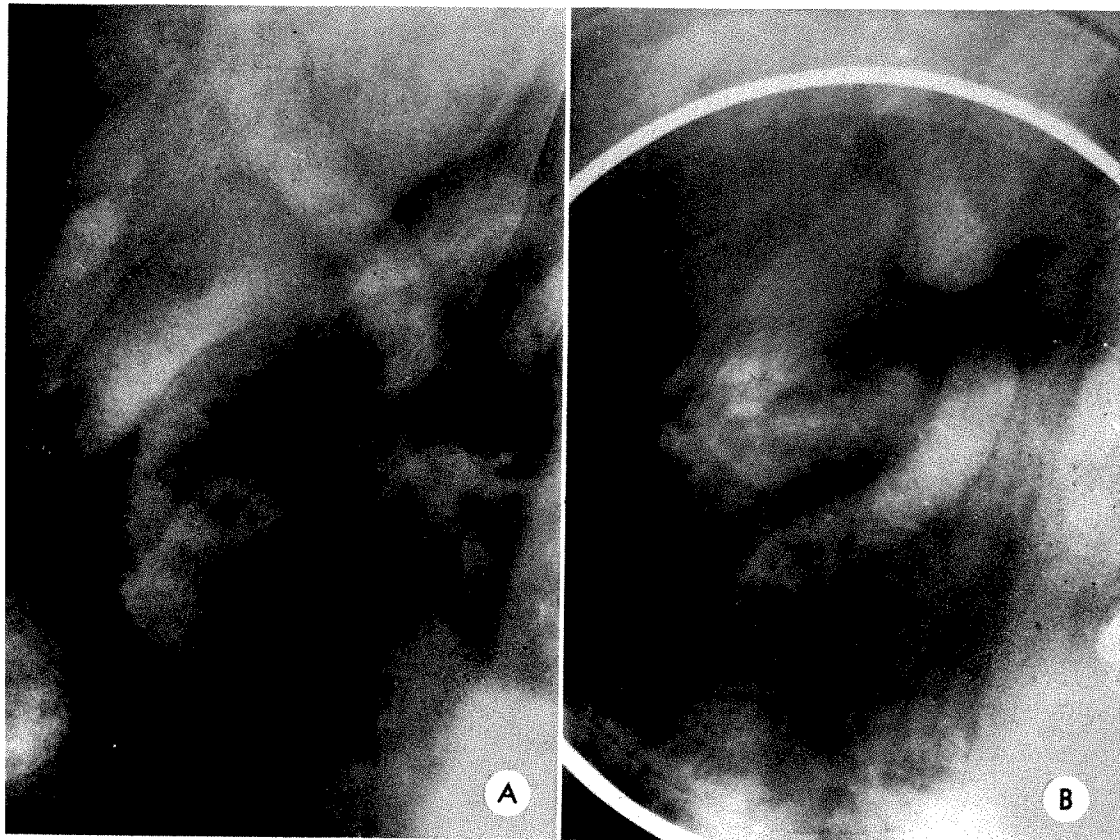


FIG. 7. Intravenous cholangiograms in a postcholecystectomized patient showing (*A*) an indistinct dilated common duct because of the overlying intestinal gas and (*B*) when the compression paddle is applied, 2 nonopaque calculi visualized near the ampullary portion of the duct.

Roentgenograms made when using the pneumatic compression paddle technique (Fig. 3, *A* and *B* through 7, *A* and *B*) point up the advantages of this procedure in certain selective situations.

CONCLUSION

Use of a pneumatic compression paddle in cholecystography and choledochography permits better visualization of normal and

abnormal findings without annoying overlying intestinal shadows and with the benefit of graded compression.

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A DOUBLE BLIND STUDY OF ORAGRAFIN AND TELEPAQUE*

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MODERN cholecystography is an examination of great utility and high reliability. The patient has not been exposed to more than minute risk nor has he experienced more than little inconvenience or discomfort.

Since the desire to improve an already good procedure is never to be deprecated, new contrast agents have recently been developed. To adequately evaluate any new cholecystographic agent, certain prerequisites of experimental design must be met. A study should be twofold, involving the comparison of (a) the side effects of the ingested medium, and (b) the efficiency of the new material in accomplishing its roentgenographic function, relative to a previous or standard agent. The two are interrelated for both the incidence of side effects and roentgenographic efficiency depend on the amount of media used. A desirable agent will produce excellent cholecystograms with a dose size which produces a minimum of side effects.

To eliminate insofar as possible subjectivity from the evaluation of a cholecystographic agent, a double blind study is essential. The evaluation of side effects as well as the evaluation of the cholecystograms should be blind, that is, the physician must not know which of the tested substances he is evaluating. Not until completion of all his assessments are the substances identified by previously assigned code number. Essential, too, is the need for the two groups of subjects to be similar in composition. Distribution of the two contrast agents in a random fashion to a large number of unselected patients of a hospital or out-patient population usually accomplishes this. The two groups should be later analyzed as to age, weight and in-

cidence of pathologic findings to insure that bias has not entered in, despite the random selection. A statistical evaluation should then be made of the tabulated findings, provided a large enough number of patients have participated to make the deductions significant.

A cross-over study in which patients are examined first with one agent and then after an interval with the other under blind conditions is an even better controlled experiment.

METHOD OF INVESTIGATION

A new cholecystographic agent, the sodium salt of B-(3-dimethylamino-methylencamino-2,4,6-triiodophenyl)-propionic acid, was compared with telepaque. The new medium has the trade name of Oragrafin (Squibb) in the United States and Biloptin (Schering, A. G., Berlin) in Europe. It is supplied in capsules (3 gm.) or as 8 gm. of a powdered preparation containing 3 gm. of the calcium compound. The compound possesses an iodine content of 61.4 per cent, a high solubility and complete absorbability. Its empirical formula is $(C_{12}H_{12}N_2O_2I_3)Na$. Initial studies by Saltzman,⁵ Whiteside,⁶ Kemp and Wright,⁷ and Brannan, Donovan and Hodgson⁸ have been published in the English language. Reports in German are included in Saltzman's bibliography; pharmacologic studies have been conducted by Kimbel and Langecker.⁴

Three gram doses of oragrafin (6 capsules) and 3 gram doses of telepaque (6 tablets) were distributed in a random manner to both in- and out-patients of all services of the University Hospital as cholecystographic examination was requested. Over 250 consecutive patients

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were studied. The radiologists, referring physicians and the individual patient were unaware which agent the individual patient had ingested. The patients were instructed identically as to the conduct of the examination. A regular supper was given, followed by ingestion of the contrast medium with a small amount of water at 7 P.M. Water was allowed until bed time. At 8 A.M. the patient was sent to the Radiology Department without breakfast. The standard recumbent and upright views of the gallbladder region were utilized, followed by coned down views in these two positions or in decubitus position if needed for diagnosis. A fat meal was given and post fat films were exposed when it appeared that information of importance could thereby be obtained.

Interviewing of the patients for their subjective response was conducted by a radiologist on the morning of the examination and the information recorded on a standard form. Side effects were graded as slight, moderate, or severe.

Films were evaluated conjointly by two radiologists for the degree of opacity of the gallbladder, presence of calculi, opacification of the cystic and common bile ducts without and following fatty meal, and presence of opaque material in the bowel and its interference with diagnosis.

When a double dose technique was re-

quested, all other elements of the study, except the size of the dose, were not changed. Excluded from the study were those examinations in which data were considered inadequate, or the complete film study was not available.

About 30 per cent of the films were given a "second look" at an interval after their first reading to check on the reproducibility of our evaluations of opacity, duct visualization, and so forth.

The statistical analysis of side effects produced by the two media was accomplished by application of the data to the following formula:

$$\frac{\text{DIFFERENCE}}{\text{STANDARD ERROR}_{\text{Difference}}} = \frac{p_1 - p_2}{\sqrt{(S.E._{p_1})^2 + (S.E._{p_2})^2}} = \frac{p_1 - p_2}{\sqrt{\frac{pq}{n_1} + \frac{pq}{n_2}}}$$

where p is the proportion of patients with side effects when the two groups were combined; q is $p - 1$; p_1 is the proportion of patients who experienced side effects with oragrafin; p_2 is the proportion of patients who experienced side effects with telepaque; n_1 is the number of patients who received oragrafin; and n_2 is the number of patients who received telepaque.

The ratio of the difference to the standard error of the difference permitted extraction of probability values from a standard table relating the ratio to areas of a normal curve. Probability values less than 0.05 were regarded as significant. Probability values less than 0.01 were considered highly significant.¹

After all studies were completed, the two groups of patients were found to be comparably distributed as to age, weight and sex.

RESULTS

The undesirable side effects produced by the two agents are noted in Table I. The incidence of diarrhea was much higher in the telepaque group. The incidence of

TABLE I
SIDE EFFECTS ENCOUNTERED (3 GM. ORALLY)

	Oragrafin	Telepaque
No. of Cases	99	105
Nausea		
Slight	10	14
Severe	2	6
Vomiting	0	1
Diarrhea		
Mild	7	22
Severe	3	16
Cramps	5	15
Dysuria	9	13
Skin reactions	0	0

nausea and cramps was slightly higher in the telepaque group.

The degree of opacification of the gallbladder was similar in the two groups (Table II).

Although calculi were more often demonstrated in the telepaque group, we do not think that stones were concealed in the oragrafin group (Table III). Dense opacification of the gallbladder which might conceal small stones was of the same incidence in the two groups.

Visualization of the biliary ducts was similar in the two groups (Table IV).

Opaque material in the bowel was found in 46 per cent of the patients of the telepaque group as compared with 9 per cent of those of the oragrafin group. In no instance did this interfere in the interpretation of the films (Table V).

The double dose study (Table VI) shows the occurrence of diarrhea with telepaque to be three times that of oragrafin and is usually severe. Cramps were associated less frequently with oragrafin than with telepaque. We found no significant differences in opacification of the gallbladder and ducts in the two groups with double doses.

From the statistical analysis, the incidence of diarrhea and cramps was significantly less for oragrafin than for telepaque ($p = <0.05$). The lesser side effects with the double dose of oragrafin as compared with telepaque was highly significant ($p = <0.01$).

COMMENT

Superiority of one cholecystographic agent over another is based upon its better

TABLE II
DEGREE OF OPACIFICATION OF GALLBLADDER

	Oragrafin	Telepaque
No. of Cases	99	105
No. visualization	10	15
1+ visualization	9	15
2+ visualization	23	16
3+ visualization	31	31
4+ visualization	24	26

TABLE III

DEMONSTRATION OF GALLBLADDER CALCULI

	Oragrafin	Telepaque
No. of Cases	93	105
Radiolucent stones	11	21
Radiopaque stones	0	2

TABLE IV

VISUALIZATION OF BILIARY DUCTS

	Oragrafin	Telepaque
No. of Cases	95	104
Ducts without fat meal	3	7
Ducts with fat meal	13	15

TABLE V

OPAQUE MATERIAL IN BOWEL; PATIENTS WITH RESIDUAL BARIUM EXCLUDED

	Oragrafin	Telepaque
No. of Cases	92	95
Opaque material in bowel		
Trace	5	29
Moderate	3	17
Interference in interpretation	0	0

TABLE VI

UNDESIRABLE SIDE EFFECTS; DOUBLE DOSE (6 GM. ORALLY)

	Oragrafin	Telepaque
No. of Cases	26	26
Nausea		
Slight	4	4
Severe	1	2
Vomiting	0	1
Diarrhea		
Mild	3	2
Severe	4	19
Cramps	1	5
Dysuria	3	5
Skin reactions	0	0

tolerance by the patient or its improvement of roentgenographic diagnosis. Of the various side effects encountered in the use of cholecystographic agents, diarrhea, vomiting and skin reactions can be more objectively evaluated than nausea, cramps and dysuria in which subjectivity participates. The comparison of the two media in regard to diarrhea shows oragrafin to have a clear-cut advantage over telepaque. Vomiting and skin reactions were so infrequent with either medium that they cannot be used as an indication of toxicity in this study. Of the subjective complaints, oragrafin gave a lesser incidence of side effects. Of these, the statistical analysis revealed the decrease in cramps to be significant. Tolerance of the patient for oragrafin is well brought out in the double dose trials, where the incidence of diarrhea and cramping was much less than by a double dose of telepaque.

We record no valid differences in the ability of the two media to opacify the gallbladder and the biliary ducts (Tables II and IV).

The contention of Whiteside⁶ that the incidence of nonopacifying gallbladders will be lower with biloptin (oragrafin) is not substantiated by our data. Since oragrafin is concentrated sufficiently by the liver to be visualized in the common bile duct,⁵ it should visualize the nonconcentrating gallbladder, provided it is able to flow into the gallbladder through a patent cystic duct. Whiteside's method of giving six capsules at night and six in the morning is a fractionated double dose study, and is not comparable to our single dose study. Since with solu-biloptin (oragrafin soluble) optimal contrast density in the bile ducts was seen at two and one-half hours in the majority of patients,⁵ frequent duct visualization would not be expected on roentgenograms timed many hours later.

Although much more residual opaque material in the bowel was seen more frequently in examinations with telepaque

than with oragrafin, at no time did any residual opaque material interfere with interpretation of the roentgenograms. It is our opinion that the importance of residual cholecystographic material in the bowel lies not in its interference with diagnosis, for it does not do so, nor in its serving as a sign that the patient ingested the agent, for other means are available to ascertain this, but in revealing only partial absorption of the agent. Incomplete and variable absorption of a cholecystographic agent is not desirable, for the opacification of the gallbladder is then less dependent on the status of the gallbladder and more a reflection of the percentage absorption.

SUMMARY

Two oral cholecystographic agents, oragrafin and telepaque, have been compared by a double blind study. The opacification of the gallbladder and bile ducts was essentially the same with the two media. Oragrafin* was superior to telepaque in causing a definite lesser incidence of diarrhea and cramping.

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* Oragrafin was supplied by E. R. Squibb and Sons, New York.

ADHERENT GALLBLADDER SIMULATING AN INTRINSIC LESION OF THE RIGHT SIDE OF THE COLON*

REPORT OF A CASE

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THE purpose of this paper is to demonstrate that a chronically inflamed gallbladder, by virtue of becoming adherent to the right side of the colon and thereby deforming it, can create a roentgenographic appearance highly suggestive of an intrinsic colonic lesion. While the roentgenographic appearance seen in this case is unusual in a patient with inflammation of the gallbladder, the diseased gallbladder has been described in the literature as having caused deformation of the duodenal bulb,³ intestinal obstruction,⁴ obstruction of the pylorus^{1,2,5} and cecum,⁶ and stricture of the transverse colon.⁷

REPORT OF CASE

A fifty-three year old Negro female was referred to the Hospital of the University of Pennsylvania for study of a mass lesion in the right side of her abdomen. She was well until seven months prior to admission when she became progressively anorexic. Six weeks prior to admission she experienced a sharp pain in the epigastrium which was relieved by leaning forward. The pain was accompanied by chills, fever, night sweats, weakness, generalized myalgia, obstipation, and vomiting. After three days, all symptoms except the pain abated. The family physician noted jaundice and the presence of a mass in the right side of the abdomen. The jaundice gradually disappeared during the two weeks prior to admission, but the mass did not change size during the following six weeks.

On admission, the patient complained of pain in the right lower quadrant. A review of the gastrointestinal system revealed nothing abnormal. The patient appeared to be chronically ill and had an oral temperature of 99.6°F.

Positive findings were limited to the abdomen where the liver was found to be 4 cm. below the right costal margin and to have a sharp, tender margin. Below the liver edge, at the junction of the right upper and lower quadrants, was a smooth, hard, non-tender spherical mass measuring 4 cm. in diameter. It appeared to lie deep in the abdomen and to move with respiration. The hemoglobin was 9 gm. per cent and the white blood cell count was 22,600 with 75 per cent neutrophils, 21 per cent lymphocytes, and 4 per cent eosinophiles. Urinalysis, liver function tests and serum chemistries were all within normal limits. The Kolmer and Kline tests were both reactive on two occasions. The electrocardiogram revealed changes suggesting myocardial or pericardial disease.

A barium enema study (Fig. 1, *A* and *B*) disclosed a complete obstruction to the retrograde flow of the barium mixture at the hepatic flexure. The opaque mixture outlined a large, irregular filling defect. Three attempts were made to fill the right side of the colon, but without success.

At operation, a large tense gallbladder was found which was surrounded by chronic inflammatory tissue. It was tightly adherent to the hepatic flexure and was causing partial obstruction due to extrinsic pressure. It was also adherent to the omentum and to the second portion of the duodenum. The inflamed gallbladder had eroded through the serous membrane and the muscularis mucosae of the hepatic flexure, but the intestinal mucosa was intact. The common bile duct was opened and found to be normal. A liver biopsy was done. The bowel was palpated externally and no masses were felt within it.

The gallbladder was filled with bloody purulent material containing a semi-solid amorphous mass, but no formed calculi were seen. Microscopically, there was thickening of the wall by

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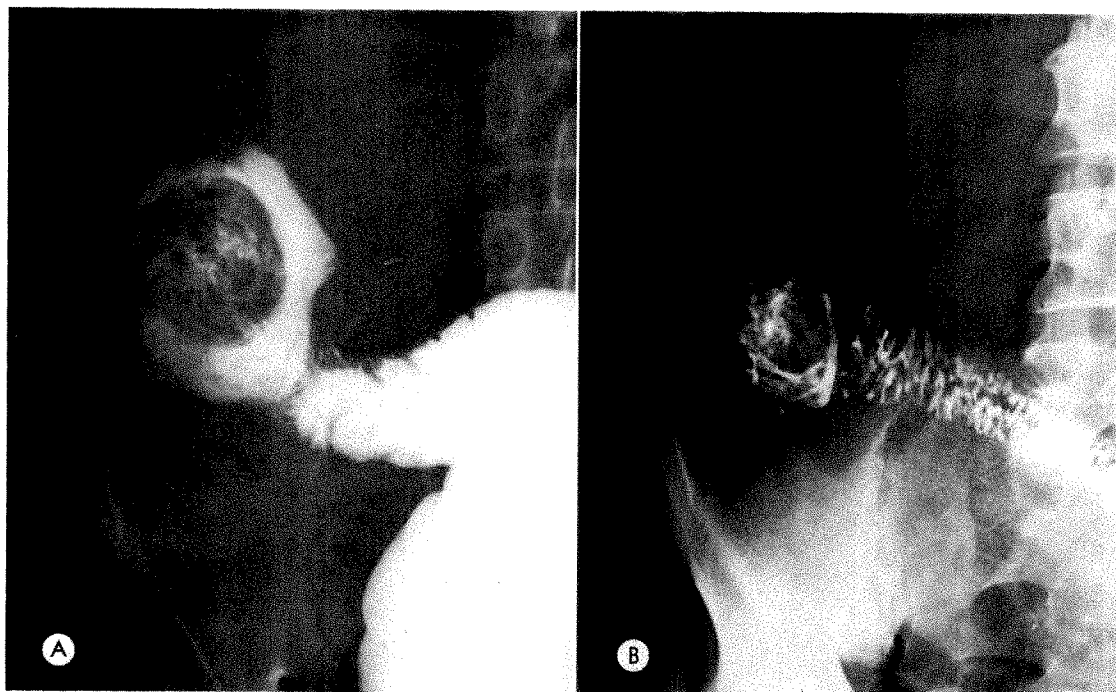


FIG. 1. (*A* and *B*) Preoperative roentgenograms showing filling defect caused by adherent gallbladder.

vascularized scar tissue. Most of the mucosa had been eroded. Sections of the liver biopsy showed periportal and subperitoneal fibrosis. The final pathologic diagnoses were chronic cholecystitis and chronic cholangitis.

Two weeks postoperatively, re-examination

by barium enema (Fig. 2, *A* and *B*) revealed a normally appearing colon.

SUMMARY

A case is presented in which chronic inflammation of the gallbladder caused de-

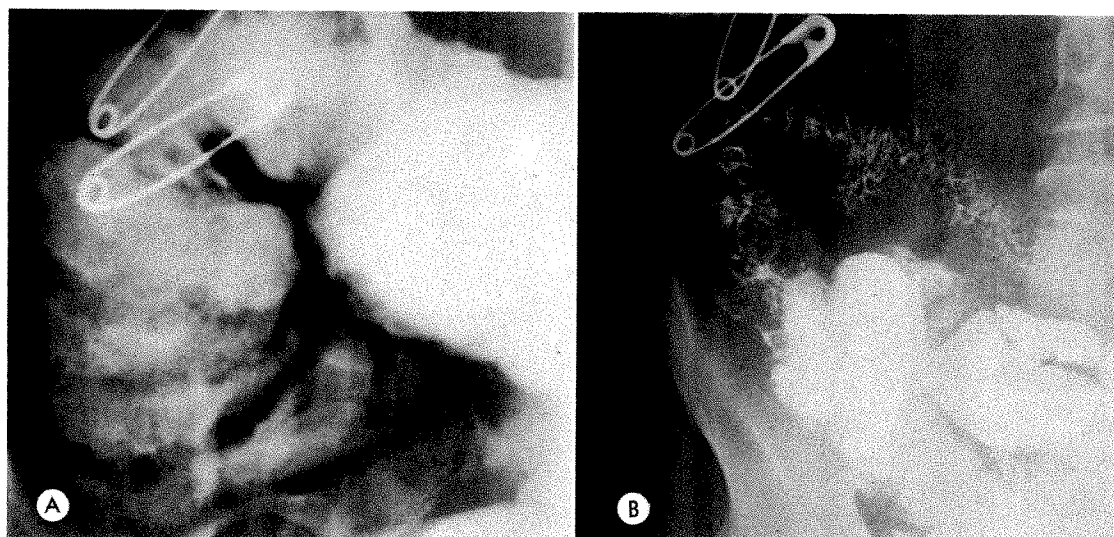


FIG. 2. (*A* and *B*) Postoperative study showing normal appearance of the right side of the colon after removal of the adherent gallbladder.

formity of the right side of the colon, the roentgenographic appearance of which was highly suggestive of an intrinsic colonic lesion.

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THE REAPPEARING GALLBLADDER*

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THE postcholecystectomy patient may occasionally show an opaque gallbladder-simulating shadow on intravenous cholangiography and in rarer instances on oral cholecystography. In these patients the possibility of a dilated cystic duct remnant with or without calculi and several other entities must enter into the differential diagnosis. Despite its clinical importance, very little attention has been given to this problem in the roentgenologic literature. The term "reappearing gallbladder" refers to dilated cystic duct remnants seen on roentgenograms. It is the purpose of this paper to discuss the reappearing gallbladder and the roentgenologic entities which may mimic it.

Writing on conditions necessitating surgery following cholecystectomy, Beye³ in 1936 reviewed 66 cases during a fifteen year period. Among these 66 cases were 14 cases of dilated cystic duct remnants for which he coined the term "reformed gallbladders." A larger series of the so-called "reformed gallbladders," consisting of 42 cases, during a seventeen year period was reported by Peterson¹³ in 1946. All of the patients in his series had recurrence of symptoms referable to cystic duct remnants and in all cases the diagnosis was surgically confirmed.

It is evident that the dilated cystic duct remnant is one of the common causes of recurrent difficulty in the postcholecystectomy patient. Until relatively recently the roentgenologic index of suspicion depended for the most part in seeing opaque biliary type calculi in a nonjaundiced patient who had previously undergone a cholecystectomy. There are a few reported cases in which a cystic duct remnant or an incompletely removed gallbladder has been opac-

ified with oral cholecystography^{1,16} and this was also noted in our Case III. With the introduction and widespread adoption of intravenous cholangiography, the reported preoperative visualization of cystic duct remnants has increased.^{2,5,8,14}

REPORT OF CASES

CASE I. J. M., a forty-seven year old white female, was admitted to the hospital in March, 1957 with complaints of gaseous distention and episodes of right upper quadrant pain. A cholecystectomy had been performed for similar symptoms nineteen years ago. Following this she had done well except for occasional fatty food intolerance. One year prior to admission she incurred increasing difficulty with fatty foods and this was followed by symptoms of gaseous distention and episodes of colicky right upper quadrant pain. She also noted an increasing degree of constipation.

Gastrointestinal series and barium enema study revealed a few duodenal diverticula and moderate diverticulitis of the descending and sigmoid colon. An additional finding was that of several small calcific densities in the right upper quadrant having the appearance of biliary calculi. An intravenous cholangiogram demonstrated a normal appearing biliary duct system and several calculi within an opacified "gallbladder" (Fig. 1).

Laparotomy was performed and the findings were those of a dilated cystic duct remnant measuring 2 cm. in its greatest diameter. This contained 8 to 10 small partially calcified, faceted calculi. The common duct was unremarkable. The dilated cystic duct remnant was freed, ligated close to the common duct and excised. The pathology report on the submitted tissue was that of chronic cholecystitis (Fig. 2).

The patient has since been free of any symptoms referable to the biliary tract.

CASE II. A. C., a forty-nine year old white female, was admitted to the hospital with a four

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FIG. 1. Case I. Laminagram made during intravenous cholangiography reveals several small opaque calculi within the dilated cystic duct remnant. The opaque density between the cystic duct remnant and the common duct represents the upper knee of the duodenum. This is sometimes misinterpreted as a reappearing gallbladder.

month history of frequent epigastric discomfort occurring shortly after meals. She had also experienced several episodes of colicky type right upper quadrant pain. Her symptoms were very similar to those present prior to a cholecystectomy ten years ago. A roentgenogram of the abdomen revealed several small shadows of calcific density in the region of the gallbladder (Fig. 3).

The patient underwent laparotomy and was found to have an approximately thumb sized dilated cystic duct remnant containing several faceted calculi. The common duct appeared normal. Her postoperative and subsequent course during the past seven years has been unremarkable.

CASE III. L. B., a fifty-five year old white female, was admitted to the hospital in 1952 with a chief complaint of episodes of right upper



FIG. 2. Case I. Photomicrograph showing chronic inflammation in the wall of the cystic duct (H & E $\times 80$).



FIG. 3. Case II. There is a cluster of small opaque densities in the right upper quadrant. At surgery numerous calculi were found in a dilated cystic duct remnant. No calculi were noted in the common duct.



FIG. 4. Case III. Oral cholecystogram shows a density lateral to the third transverse process. It was felt to represent a calculus, possibly within a cystic duct remnant. At surgery a small remnant of the gallbladder as well as the cystic duct was found with no evidence of calculi (see Fig. 5).

quadrant pain during the past five years. She had also noted fatty food intolerance and would frequently vomit if she ate large meals. A cholecystectomy had been done twelve years previously.

Concomitant gastrointestinal series and oral cholecystography (priodax #10) were done in which the gastrointestinal examination was normal. The biliary tree could not be outlined, but there was an opaque shadow about 1 cm. in diameter in the approximate location of the gallbladder (Fig. 4). With different projections it moved away from the kidney and was therefore felt to represent a biliary calculus.

At laparotomy a small dilated gallbladder remnant and cystic duct were found and measured 3×1 cm. No calculi were seen. The gallbladder remnant contained a small amount of bile and the cystic duct was patent. The pathology report was that of chronic cholecystitis.

A postoperative roentgenogram of the abdomen was obtained due to the fact that no calculi were found at the time of surgery. This roentgenogram no longer showed the shadow resembling a calculus and it was therefore felt

that the earlier finding represented opaque medium within the dilated gallbladder remnant (Fig. 5).

The patient has had no symptoms suggestive of recurrent biliary tract disease during the past eight years.

CASE IV. A. D., a sixty-five year old white female, was first admitted to this hospital in 1946 with symptoms consistent with cholecystitis. An oral cholecystogram showed poor opacification of the gallbladder with no evidence of calculi. She responded well to conservative medical management. However, one month later a similar episode occurred and a cholecystectomy was performed. At surgery no calculi were found and the pathology report on the submitted tissue was that of chronic cholecystitis. Her postoperative course was uneventful and during the following year she had no recurrence of symptoms.

In 1957 the patient was admitted to the hospital for evaluation and treatment of a convulsive disorder. Electroencephalograms, skull roentgenograms, pneumoencephalograms and cerebral angiograms did not establish a definitive etiology for the seizures. She had also experienced anginal type pain for several months.

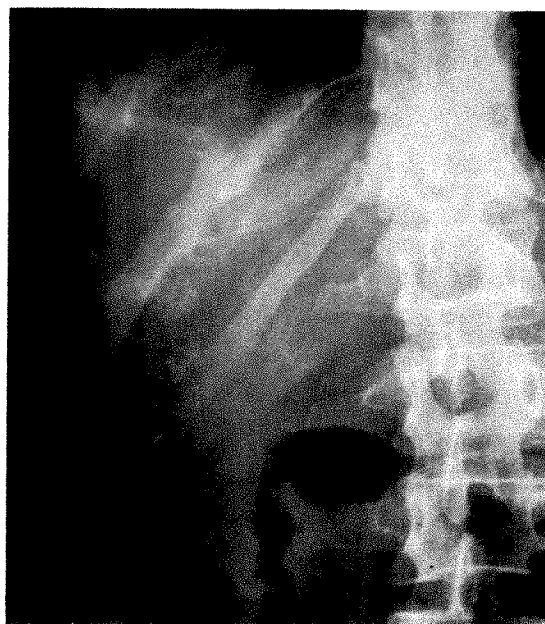


FIG. 5. Case III. A postoperative roentgenogram no longer shows the density seen in Figure 4. It is therefore felt that the preoperative right upper quadrant density represented opaque medium within the gallbladder remnant.

An electrocardiogram was interpreted as suspicious of an old posterior myocardial infarction.

On a roentgenogram of the abdomen, numerous small calcific densities were noted in the right upper quadrant (Fig. 6). These were not in the kidney and had the appearance of biliary calculi. An intravenous cholangiogram on which the main hepatic and common ducts were visualized appeared normal. The collection of calculi was lateral to the common duct and in the position of a gallbladder (Fig. 7). The patient had no symptoms referable to this finding and was discharged with medications to help control the seizures and anginal symptoms.

In 1959 the patient was admitted to the hospital because of severe epigastric pain. The pain had begun while she was eating supper. It radiated to the back and the left side of the chest. The epigastric area was tender to palpation and the bowel sounds were normal. The white blood cell count was not elevated but showed a shift to the left on the differential. An electrocardiogram revealed no evidence of a new myocardial infarction. The serum amylase was normal and a gastrointestinal series was

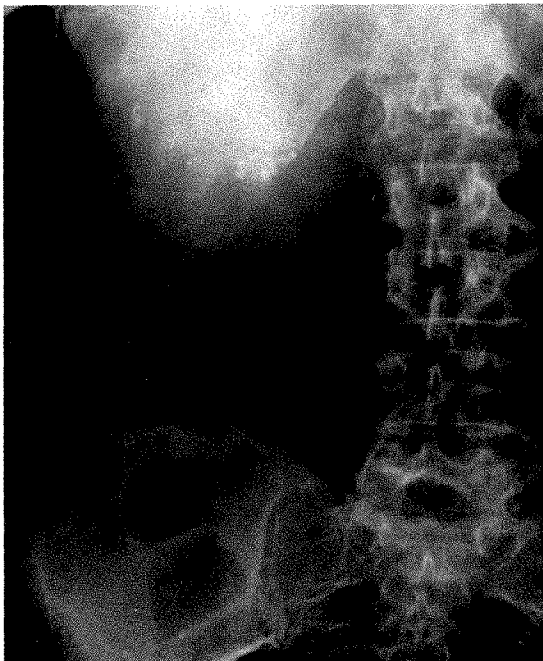


FIG. 6. Case IV. The patient had a cholecystectomy sixteen years before this roentgenogram was made. In other projections the cluster of calcific densities in the right upper quadrant can be separated from the right kidney (see Fig. 7).



FIG. 7. Case IV. Intravenous cholangiogram shows the main hepatic and common ducts to appear normal. The calculi are located lateral to the common duct in the position usually occupied by the gallbladder. Laparotomy was deferred because of the cardiac status of this patient.

unremarkable. An intravenous cholangiogram showed identical findings with the examination of two years ago.

It was felt that her symptoms were due to inflammation within a dilated cystic duct remnant. The possibility of a double gallbladder, with one being overlooked at the time of previous surgery, was entertained but seemed less likely. The patient had been treated five months ago at another hospital for a silent myocardial infarction. On this admission she was hypertensive and exhibited peripheral edema. Therefore surgery was deferred at this time. She responded well to medical management and was discharged five days after admission.

During the past eighteen months she has been on a low fat diet and has had no symptoms referable to the biliary tract.

CASE V. R. P., a fifty-nine year old white male, was hospitalized in 1953 with symptoms

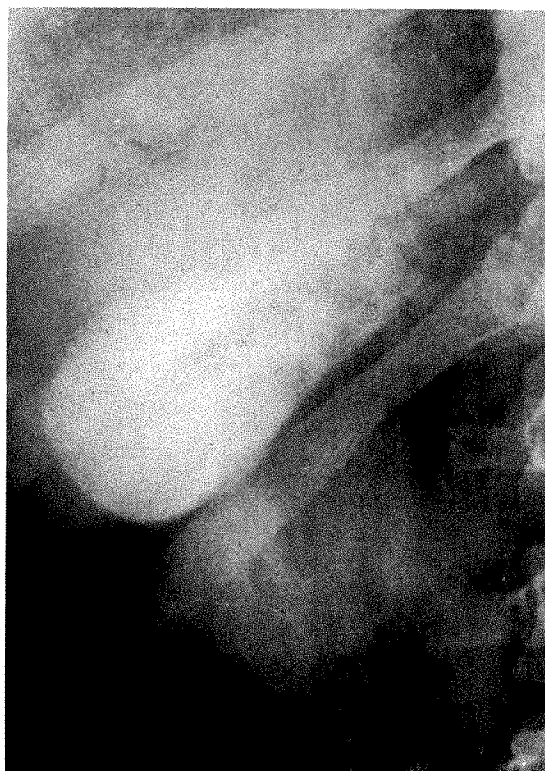


FIG. 8. Case v. Oral cholecystogram shows numerous nonopaque calculi. The patient subsequently had his first cholecystectomy.

suggesting gallbladder disease. The oral cholecystogram showed concentration of the medium with numerous nonopaque calculi within the gallbladder (Fig. 8). A cholecystectomy was done and confirmed the roentgenographic findings. The operative note states that the cystic duct was identified, freed from surrounding tissue and doubly ligated. The postoperative course was uneventful.

The patient had no symptoms referable to the biliary tree until March, 1961. At this time he experienced vague pain in the right central abdomen lasting four days. This prompted hospital admission where a survey roentgenogram of the abdomen revealed several small opaque calculi in the right upper quadrant. A gastrointestinal series gave normal findings.

A three day concentration study, using daily doses of iopanoic acid (telepaque) was done. Roentgenograms on the third day showed concentration of the medium in a 3×4 cm. pear-shaped structure in the right upper quadrant. The opaque calculi were within this structure

(Fig. 9). This was felt to represent a dilated cystic duct remnant with calculi.

An operation was performed with removal of a saccular structure 3×2.5×0.5 cm. which apparently represented a remnant of the cystic duct. Several partially calcified calculi were present (Fig. 10). The microscopic examination revealed changes of chronic inflammation of the cystic duct.

The patient was discharged on the sixth post-operative day and has remained well.

DISCUSSION

Not all patients with dilated cystic duct remnant- are symptomatic. Therefore it is difficult to evaluate the true incidence of this condition. Berk and Lee² in tabulating 515 cases of symptomatic postcholecystectomy patients included 44 cases of reappearing gallbladder or an incidence of 8.6

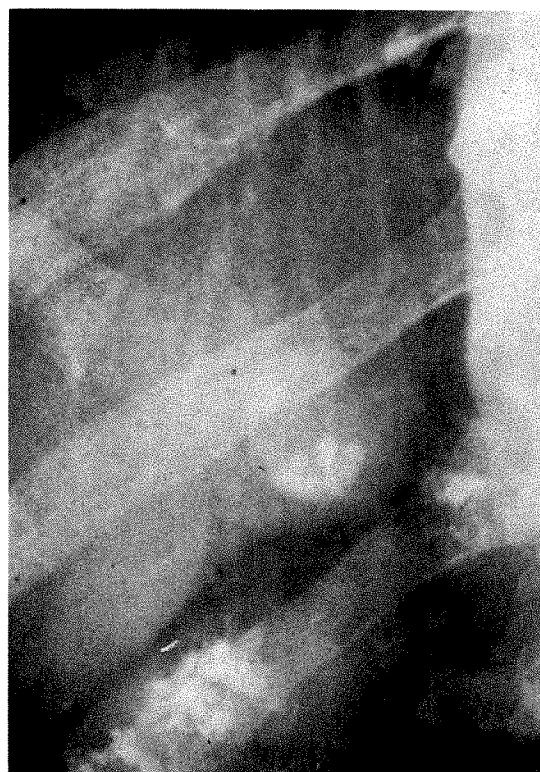


FIG. 9. Case v. Eight years after the cholecystectomy, a three day concentration cholecystogram shows opaque calculi within the "reappearing gallbladder."

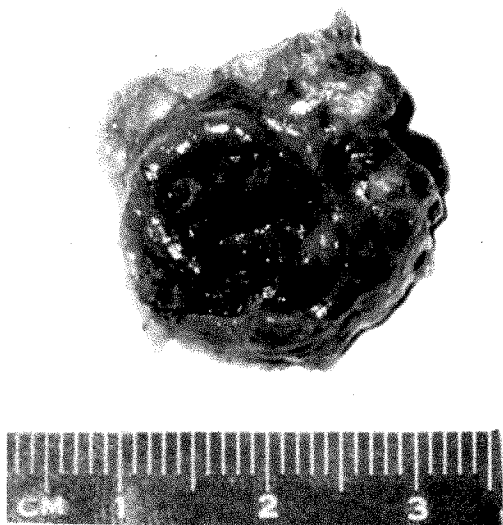


FIG. 10. Case v. The opened surgical specimen reveals several partially calcified calculi within the saccular structure.

per cent. Of these 44 cases, 13.6 per cent had associated calculi. If one limits the selectivity to symptomatic postcholecystectomy patients requiring further surgery, the incidence is still higher. In Beye's³ series of 66 cases which fall into this category 14 or 21 per cent had cystic duct remnants.

There are several reasons why at the time of surgery the cystic duct may be ligated at too great a distance from the common duct and thus result in a cystic duct remnant. The operative field may be such that possible injury to the common duct outweighs the factor of leaving a residual cystic duct. Frequently, the first part of the cystic duct is adjacent to and parallels the common duct for a short distance and this may not be appreciated at the time of surgery. Inadequate exposure of the cystic duct during surgery may result in its ligation at a point too far from the common duct. The surgeon may err in judgment and leave more of the cystic duct than is desirable.

With the increasing awareness of this entity and the continued refinements in surgical techniques, we would suspect that

this entity will be encountered less frequently in the future.

The causative factor for cystic duct remnants to undergo subsequent dilatation has not been established. It has been postulated by Livingston and Livingston⁹ that in the postoperative period following cholecystectomy there is dilatation of the bile ducts secondary to the temporary spasm at the sphincter of Oddi. This concept has received less than unanimous acceptance. These authors feel that the cystic duct also undergoes dilatation and acts as a receptacle for bile. The dilated stump is unable to contract and stagnation of bile may occur with subsequent infection, inflammation and possible calculi formation. Peterson¹³ does not feel that the back pressure from the common duct following cholecystectomy is sufficient to cause secondary dilatation of the cystic duct remnant. He proposes that calculi are the basis for the subsequent dilatation. While this would help explain the frequency of associated jaundice in these patients, one would also expect to find an almost equal frequency of associated calculi at the time of surgery. It does not seem plausible to assume that over 50 per cent of patients having jaundice sometime between the onset of symptoms and subsequent surgery should spontaneously clear themselves of biliary calculi.

The recurrence of symptoms from a reappearing gallbladder may begin shortly after the cholecystectomy or many years later. One reported case had return of symptoms twenty-seven years following the original surgery.¹¹ In most respects the patients' complaints are very similar to those of the original gallbladder disease. The most common symptom is episodes of colicky type right upper quadrant pain. This is frequently associated with radiation of the pain to the right scapula. Nausea, vomiting, intolerance to fatty foods and gaseous distention are all common complaints. Jaundice is present sometime during the symptomatic period in about 50 per cent

of the cases. Although the etiology of the jaundice has not been adequately explained, it clears and does not recur following removal of the reappearing gallbladder.

On roentgenograms the reappearing gallbladder resembles a miniature gallbladder in the right upper quadrant. Frequently, it assumes a more horizontal position than the gallbladder. Its size varies from 1.5 to 7 cm. in length and from .5 to 3 cm. in width as compared to a normal cystic duct diameter of .2 to .3 cm. During intravenous cholangiography the opaque medium may remain within the dilated cystic duct remnant long after it has disappeared from the common duct. Laminagraphy is of considerable help in improving visualization of a suspected reappearing gallbladder. Opaque or nonopaque calculi can occur in association with the reappearing gallbladder. The ratio of opaque to nonopaque calculi is higher in this entity than in primary gallbladder disease.

A fairly common finding during intravenous cholangiography is retrograde filling of the duodenal bulb and loop. Medium in the bulb or upper knee of duodenum can mimic a reappearing gallbladder. Naegele and Huwe¹² were able to demonstrate contrast medium in the duodenal bulb 25 times and in the upper knee 19 times in a series of 103 intravenous cholangiograms done on postcholecystectomy patients. Frommhold⁶ feels that contrast medium within the duodenal bulb will usually overlie the course of the common duct and is more likely to create a diagnostic problem. In most instances the reappearing gallbladder lies further lateral to the common duct than the above entities. Should a diagnostic problem exist, it can quickly be solved by a few swallows of barium suspension.

Other conditions such as atypical duodenal diverticula, cold abscess, diverticula of the common duct and superimposition of the liver and upper pole of the kidney may occasionally cause diagnostic difficulties. However, with the added selective use of a survey roentgenogram of the abdomen,

laminagrams or a gastrointestinal series, the correct diagnosis can usually be made.

SUMMARY

The dilated cystic duct remnant is one of the common causes of recurrent symptoms in the postcholecystectomy patient. The roentgenologic diagnosis of this condition has been greatly enhanced by the use of intravenous cholangiography. Its incidence, etiology, symptomatology and roentgenologic appearance have been discussed. Simulating entities with methods for differential diagnosis have been described. The term "reappearing gallbladder" has been introduced to represent the dilated cystic duct remnants seen on roentgenograms.

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MILK OF CALCIUM RENAL STONE

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MILK of calcium in a renal calyceal diverticulum has not previously been reported in the radiologic literature. Two isolated case reports of this condition have appeared recently in the urologic literature. A review of the English literature failed to reveal any other case reports.

Churchman¹ in 1911 was apparently the first to describe the presence of limy bile in the gallbladder. Volkmann² coined the term "Kalkmilchgalle" (milk of calcium bile). Cohen³ and Simmonds⁴ have reported a total of 3 cases of milk of calcium bile in the common bile duct associated with impacted calculi at the ampulla of Vater.

Yow and Bunts⁷ in 1955 reported 19 cases of calyceal diverticula and found 82 additional cases on reviewing the literature at that time. A calyceal diverticulum is a saccular structure containing urine and connected to an adjacent calyx by a narrow isthmus. These structures have also been called calyceal cysts and pyelogenic renal cysts. They are lined with transitional epithelium continuous with that of the calyx. Their origin is unknown but is generally attributed either to prior infection or to a developmental malformation. Many patients with calyceal diverticula are symptom free but of Yow and Bunt's 19 cases, 14 had pain, and 10 had pyuria; 10 of the diverticula contained calculi.

Howell³ and Walker *et al.*⁶ each reported a case of milk of calcium in a renal calyceal diverticulum. They emphasize that the diagnosis of this condition is made by the calcium assuming a fluid level on an upright or lateral decubitus roentgenogram.

Milk of calcium is a precipitate of calcium carbonate which is heavier than either bile or urine and will therefore be layered in the most dependent portion of the gallbladder or renal diverticulum on upright or decubitus roentgenograms. It has not been



FIG. 1. Supine preliminary roentgenogram demonstrating a faint 2.0×2.5 cm. calcification overlying the right renal shadow.

explained why this calcium precipitate remains fluid rather than solidifying into the more usual type of biliary or renal calculi.

REPORT OF A CASE

The patient is a forty-five year old white female who was referred for urologic evaluation in 1956 because of left flank pain and pyuria. Physical examination was essentially unremarkable. Intravenous pyelography revealed what appeared to be a single calculus measuring 2.0×2.5 cm. in a calyceal cyst or diverticulum of the right kidney. Retrograde pyelograms confirmed this impression. Split specimens obtained from the right and left kidneys showed 0-1 white blood cells per high power field. Cultures of these specimens revealed no growth of acid fast or other bacilli. The bladder urine contained 80-85 white blood cells per high

power field. *Aerobacter aerogenes* was cultured from the bladder urine and responded to Gantrisin therapy.

Since the patient was subjectively and objectively asymptomatic after treatment for cystitis, it was decided to repeat the urograms at intervals. Surgical intervention would be indicated if severe pain, persistent infection, or parenchymal destruction took place.

The patient remained asymptomatic until May, 1961 at which time she appeared at the office complaining of right back pain. Intravenous pyelography revealed no change from previous studies. An orthopedic consultation was obtained because the pain did not seem to be of renal origin. The clinical diagnosis of chronic lumbosacral strain was made and roentgen examination of the spine was requested. The upright roentgenogram demonstrated a half-moon shaped calcified opacity in the same

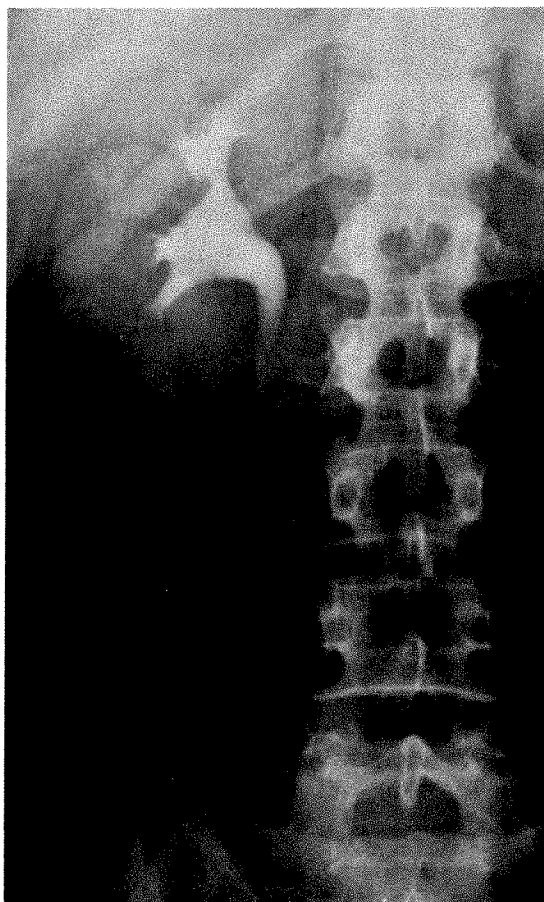


FIG. 2. Five minute intravenous pyelogram revealing no definite concentration of contrast medium in the calyceal diverticulum.

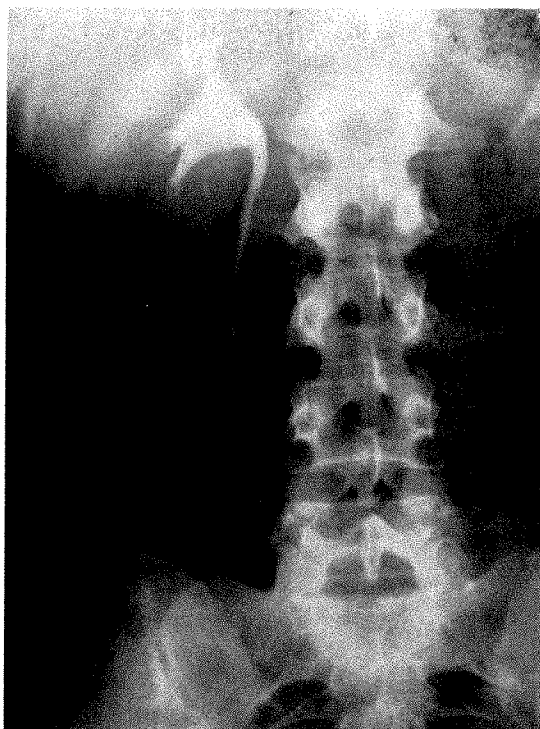


FIG. 3. Twenty minute intravenous pyelogram demonstrating a definitely increased opacity of the diverticulum, thus proving a communication with the renal collecting system.

area where the renal calculus had previously been demonstrated. Decubitus roentgenograms confirmed the impression of a shifting fluid level. Gallbladder studies proved that the calcification was outside the biliary tract. The diagnosis of renal milk of calcium stone was made.

DISCUSSION

Our case demonstrated a solitary 2.0 × 2.5 cm. calyceal diverticulum (Fig. 1) apparently communicating with the middle calyceal system of the right kidney. The connecting isthmus was not well demonstrated on either intravenous or retrograde urograms; however, the presence of a communicating channel was certain because of the delayed concentration of contrast medium in the diverticulum on a 20 minute intravenous pyelogram (Fig. 2 and 3). The supine pyelograms revealed what appeared to be a solid, though only slightly opaque, calculus filling the calyceal diverticulum. It

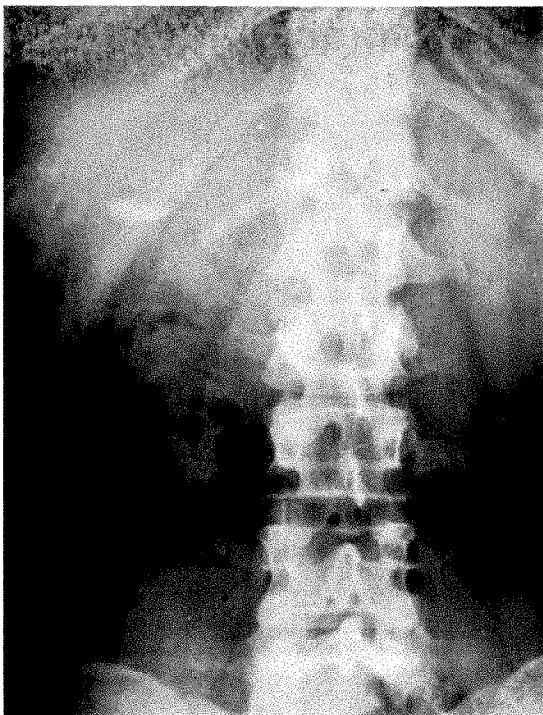


FIG. 4. Upright plain roentgenogram revealing layering of the milk of calcium.

was not until upright roentgenograms of the spine were fortuitously obtained that the presence of milk of calcium in the calyceal diverticulum was demonstrated (Fig. 4). A gallbladder examination was obtained to convince skeptical colleagues that the milk of calcium was not in the gallbladder (Fig. 5). Decubitus gallbladder roentgenogram again demonstrated layering of the milk of calcium in the renal diverticulum (Fig. 6).

TREATMENT

The management and treatment of calcium milk stones is based on subjective and objective findings. Intelligent neglect is the treatment of choice when the patient is asymptomatic and there is no pyuria. Surgical intervention should take place when there is characteristic pain and/or persistent pyuria from the involved kidney. Surgery should consist of eradication of the diverticulum lining and obliteration of the communicating channel.



FIG. 5. Upright lateral gallbladder study revealing the layering of milk of calcium lying posteriorly in the kidney.

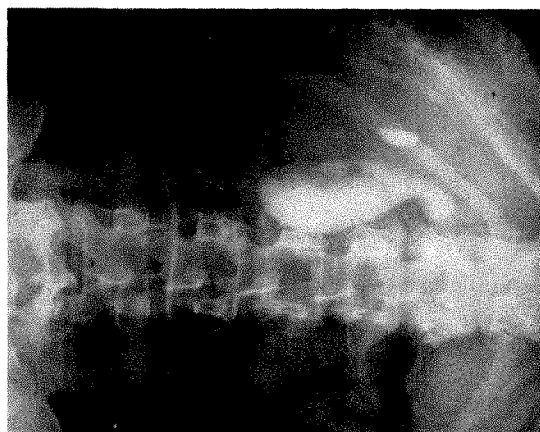


FIG. 6. Left lateral decubitus gallbladder study also demonstrating the milk of calcium outside the gallbladder shadow.

SUMMARY

This is a case report, the third in the literature, of milk of calcium in a calyceal diverticulum of the kidney. The necessity of upright or decubitus roentgenograms to demonstrate this condition is emphasized.

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THE SIGNIFICANCE OF THE LATERAL VIEW IN T-TUBE CHOLANGIOGRAPHY*

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THE recent introduction of biliary tract endoscopy at Montefiore Hospital has placed a new responsibility on the radiologist—namely, to furnish the operating surgeon with precise anatomic data concerning the major hepatic ducts. The American radiologic literature contains a surprising paucity of references relating to the detailed roentgen anatomy of the hepatic ductal system. A major European contribution in this field was Norman's⁵ work in 1951, while Healey and Schroy¹ emphasized the frequency of normal variations in the hepatic ductal system.

The operating surgeon inserting a choledochoscope into the common duct (when ever choledochotomy is required during a cholecystectomy) may direct his instrument toward the duodenum, as well as the proximal end of the common duct. In the latter direction, he encounters a rather complicated system of ductal divisions and subdivisions. It is incumbent upon the radiologist to facilitate the surgeon's orientation in this area in order that he may properly guide his choledochoscope, and also know the limitations of his tool. In order to be of help in this important area, we have attempted to define the most fre-

quently encountered patterns of ramification in the hepatic ductal system.

In most radiology departments T-tube cholangiography is limited to anteroposterior and oblique projections on fluoroscopic 'spot' films and conventional roentgenograms. However, since the hepatic ducts are three dimensional structures, their roentgenographic evaluation without a lateral projection is incomplete, just as a roentgenographic evaluation of the chest or a bronchogram would be inadequate without a lateral view. The introduction of the lateral view in T-tube cholangiography in the fall of 1960 in our department has had unexpected rewards both in the delineation of the anatomic branchings of the hepatic ductal system and in the detection of such abnormalities as cystic duct stumps.

One hundred T-tube cholangiograms have been reviewed and analyzed, and the following data regarding the normal roentgen anatomic structural make-up of the hepatic ductal system were assembled.

THE HEPATIC DUCTAL SYSTEM

The common hepatic duct is formed by the junction of the right and left hepatic ducts (Table I and Fig. 1). Analogous to the

TABLE I
ROENTGEN ANATOMY OF HEPATIC DUCTAL SYSTEM

COMMON HEPATIC DUCT	RIGHT HEPATIC DUCT	DORSOCAUDAL BRANCH
		VENTROCRANIAL BRANCH
	LEFT HEPATIC DUCT: NO CONSTANT RAMIFICATION (see text)	

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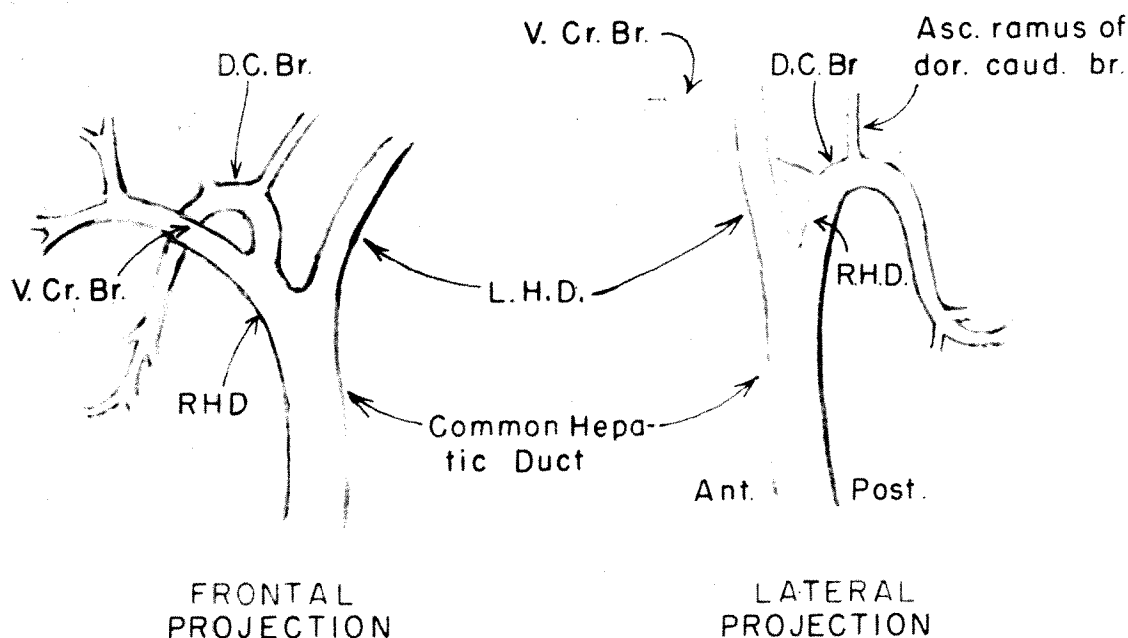


FIG. 1. Schematic composite of the roentgen anatomy of the hepatic ductal system in its most common configuration. D.C.Br.=dorsocaudal branch. V.C.Br.=ventrocranial branch. (From Schein, Stern and Jacobson, *Surgery*.⁷)

bronchial tree, we have referred to this uncton as the carina.

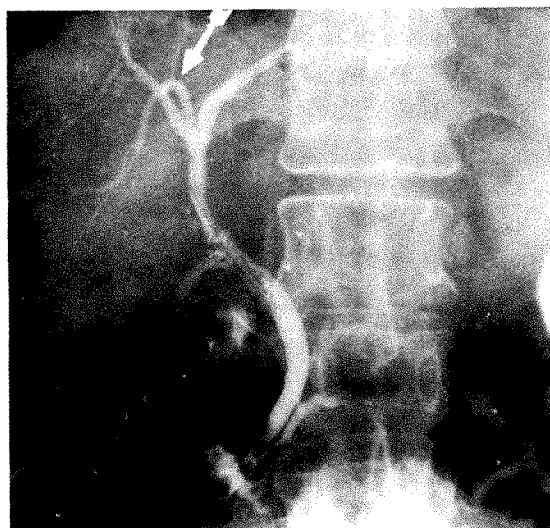


FIG. 2. T-tube cholangiogram, frontal projection. Normal T-tube cholangiogram. The arrow points to the characteristic hook of the dorso-caudal branch of the right hepatic duct. This hook represents an obstacle to the endoscopist. The lumen of the left hepatic duct is slightly wider than the right.

THE RIGHT HEPATIC DUCT

Lateral roentgenograms show the right hepatic duct to be posterior to the left hepatic duct (Fig. 3). Lateral views further show to best advantage the major division of the right hepatic duct into dorsocaudal and ventrocranial branches (Fig. 4). While the average right hepatic duct measures about 2 cm. in length, its division into the above branches may occur so close to the carina (*i.e.*, the right hepatic duct proper may measure only several millimeters in length) that the branching may suggest a trifurcation rather than a bifurcation of the common duct. The central portion of the dorsocaudal branch presents a characteristic "hook-like" configuration (Fig. 2) prior to coursing peripherally in a dorsal and caudal direction. This "hook" represents an obvious obstacle to the endoscopist who cannot pass his instrument beyond it. The peripheral portion of the dorsocaudal branch can, therefore, be evaluated only roentgenographically. Lateral views show it to have a typical curve with an inferior



FIG. 3. T-tube cholangiogram, lateral projection. The relationship between the main hepatic ducts is well shown. The anterior, branchless duct is the left hepatic duct. The branching right hepatic duct is posteriorly located. The entire hepatic ductal system is dilated and contains multiple radio-lucent calculi.

convexity (Fig. 4; 5; 12, *A* and *B*; and 13, *A* and *B*). From its "hook" the dorsocaudal branch gives off a rather constant ascending ramus which is often obscured in the frontal projection by the overlying left hepatic duct and better evaluated on the lateral projection. The ventrocranial branch of the right hepatic duct begins to arborize about 3 cm. above its junction with the dorsocaudal branch. To the endoscopist, who can see into the lumen of the ventrocranial branch for a distance of 2–2.5 cm., it appears as a tube with no major orifices.

Lobular or segmental hepatic ductal disease can be precisely localized with the aid of the lateral cholangiogram. Thus, we have encountered segmental dilatation of the right hepatic ductal system, involving only the dorsocaudal branch (Fig. 6, *A* and

B). Such dilatation is generally attributed to a calculus or stricture in the central portion of the dorsocaudal branch.

Occasionally, an accessory branch is seen to arise in the depth of the right lobe of the liver, inserting into the lower portion of the common duct (Fig. 7).

THE LEFT HEPATIC DUCT

The left hepatic duct is longer and wider than the right. Lateral views show the left hepatic duct to lie anterior to the right (Fig. 3) and in direct line with the common



FIG. 4. T-tube cholangiogram, lateral projection. The bifurcation of the right hepatic duct into dorsocaudal and ventrocranial branches is well shown (arrow). The dorsocaudal branch describes a typical curve with an inferior convexity. The upper end of the T-tube has entered the left hepatic duct.

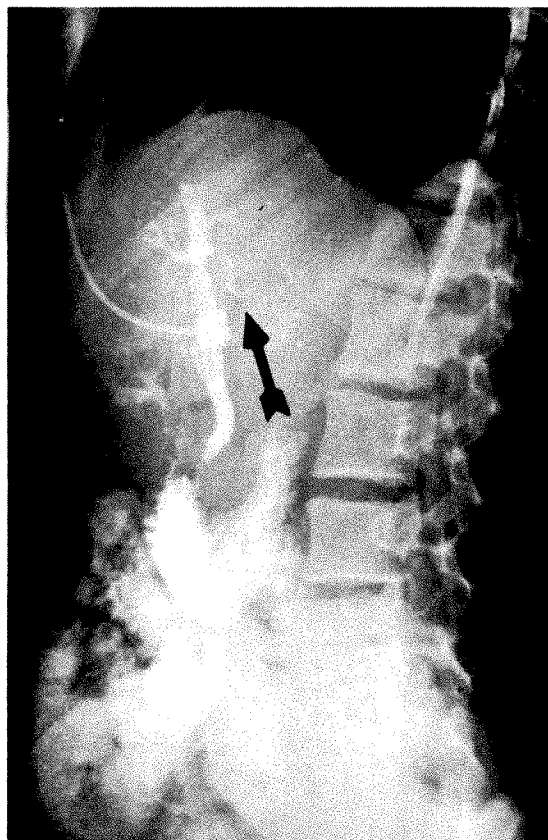


FIG. 5. T-tube cholangiogram, lateral projection. The arrow indicates the curve of the dorsocaudal branch with its convexity downward.



FIG. 6. (*Below*) T-tube cholangiograms, frontal (*A*) and lateral (*B*) projections. Segmental dilatation of the hepatic ductal system involving only the dorsocaudal branch of the right hepatic duct (arrows).

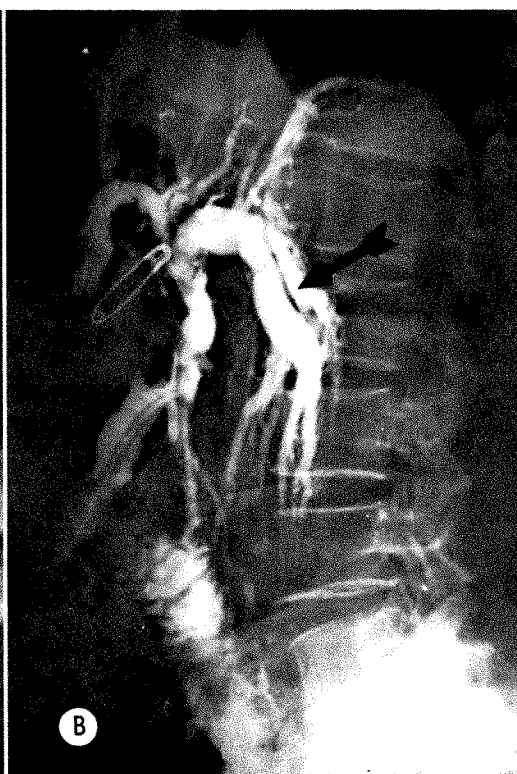
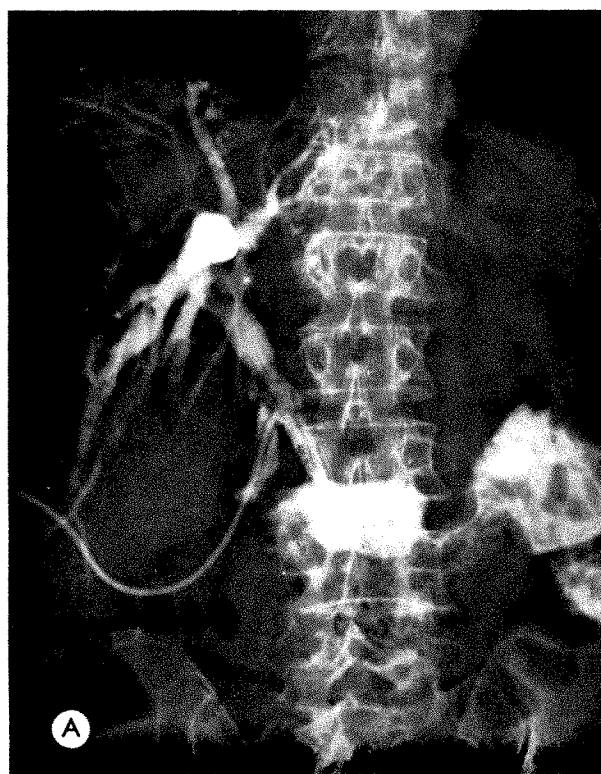




FIG. 7. T-tube cholangiogram, frontal projection. An accessory hepatic duct (arrow) arising from the right lobe of the liver is seen to enter the distal portion of the common duct. It is a normal variation.

←



FIG. 8. T-tube cholangiogram, frontal projection. Moderate obstructive choledochopathy due to a calculus in the distal end of the common duct. Under such circumstances, the left hepatic duct is generally more dilated than the right. Note the arborization of the right hepatic duct as opposed to the branchless configuration of the left hepatic duct.

←



FIG. 9. T-tube cholangiogram, right posterior oblique projection. Obstructive choledochopathy showing the peripheral dilatation of the left hepatic duct, which is tortuous; so-called "sigmoidization" of the left hepatic duct (arrow).

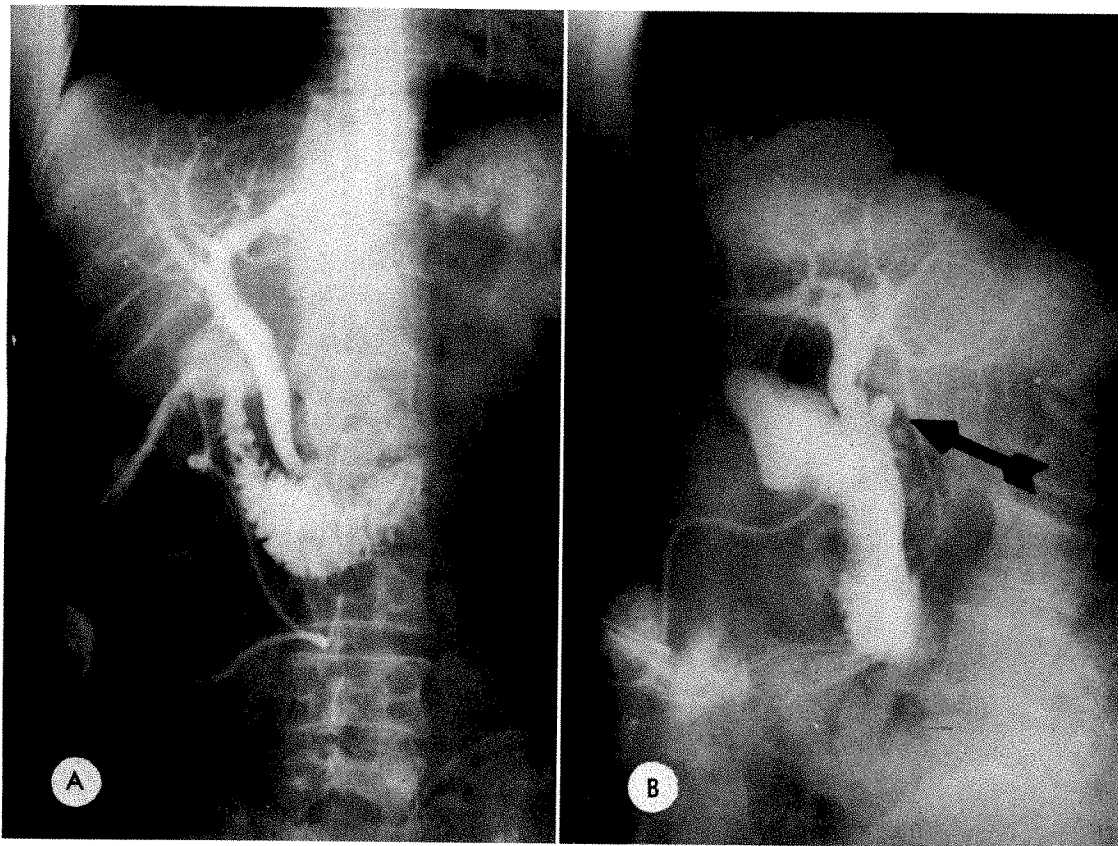


FIG. 13. T-tube cholangiograms, frontal (A) and lateral (B) projections. Another example of a cystic duct stump, seen only in the lateral projection (arrow).

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ROENTGENOLOGIC STUDY OF THE TOPOGRAPHY OF THE CHOLEDOCHO-DUODENAL JUNCTION*

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CHOLANGIOGRAPHY has been recognized as a valuable diagnostic procedure by which the patency of the biliary ducts can be demonstrated after exploration and removal of stones from the common duct. During routine T-tube postoperative cholangiographic studies aberrant sites of entry of the common duct into the duodenum were observed. Since these aberrations were not altogether rare and their possible pathologic significance had not previously been investigated, it seemed of interest to study their incidence in a group of patients in whom a T-tube was inserted after exploration of the common duct.

MATERIAL AND METHODS

A series of 122 postoperative T-tube cholangiograms was analyzed. The cholangiography was performed in all cases with the same focus-film distance of 3 feet, and in strict anteroposterior position. In all cases 15 ml. of 35 per cent diodrast was injected and the first exposure was obtained during the last phase of the injection. If necessary, further exposures were made with or without additional injection of contrast material.

The entry of the common duct into the duodenum was noted. The entry was considered as normal when its location corresponded to that described in the textbooks of anatomy and surgery;^{1,2,4,6,10,12,13} namely, in the middle of the second portion of the duodenum. An entry at the junction of the second and lower horizontal portion was considered a slight aberration and designated as "angle entry" (Fig. 1, *A* and *B*). Marked aberration was considered an entry into the third portion of the duo-

denum; this was designated as "horizontal entry" (Fig. 2, *A* and *B*).

In addition, the topographic relation of the cholechocho-duodenal junction to the lumbar vertebrae was studied. For this purpose the landmarks chosen were the transverse processes and the area comprising the mid-portion of the vertebrae (ML_n) and the intervertebral disk and $\frac{1}{4}$ of the vertebrae proximal and distal to it (DL_{n-n+1}).

Finally, the combined length of the hepatic and common duct was measured.

RESULTS

The analysis of the 122 cholangiograms revealed that the cholechocho-duodenal junction was located in 74.2 per cent (89 cases) at the site described usually in texts of anatomy namely, the midportion of the descending duodenum. In 17.8 per cent (23 cases) an "angle entry" and in 8 per cent (10 cases) a "horizontal entry" were observed.

The study of the relation of the cholechocho-duodenal junction to the lumbar spine revealed that 68 out of the 89 "normals" had an entry at the level of DL_{2-3} or above, while 6 out of 23 with "angle entry" and only 2 out of 10 with "horizontal entry" were found at the level of DL_{2-3} and none above it (Fig. 3). A correlation between the combined length of the hepatic and common ducts and the site of entry (Fig. 4) revealed that in a "normal entry" a measurement above 11 cm. was observed in 14.6 per cent only, as compared to 56.5 per cent in "angle entry" and 70 per cent in "horizontal entry." The range of the combined length varied in the cases with "normal entries" between 7 and

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hepatic duct. This alignment explains the frequent entry of the upper limb of the T-tube into the left hepatic duct (Fig. 4). Such occurrence is best prevented by making a short upper limb to the T-tube (again in analogy with the tracheobronchial tree, in which the tracheotomy tube must not be too long in order not to impinge on the carina or enter a mainstem bronchus). The left hepatic duct courses superiorly and to the left. In sharp contrast with the right hepatic duct, it generally has an almost branchless appearance, probably related to the smaller size of the left lobe of the liver (Fig. 8). Occasionally, the left hepatic duct presents multiple small branches, a so-called "centipede" appearance (Fig. 10). Sometimes the left hepatic duct will show a terminal division into two branches of equal size (Fig. 11).

Due to its longer extrahepatic course, the left hepatic duct has greater potential for dilatation than the right hepatic duct, the latter being surrounded by buttressing liver

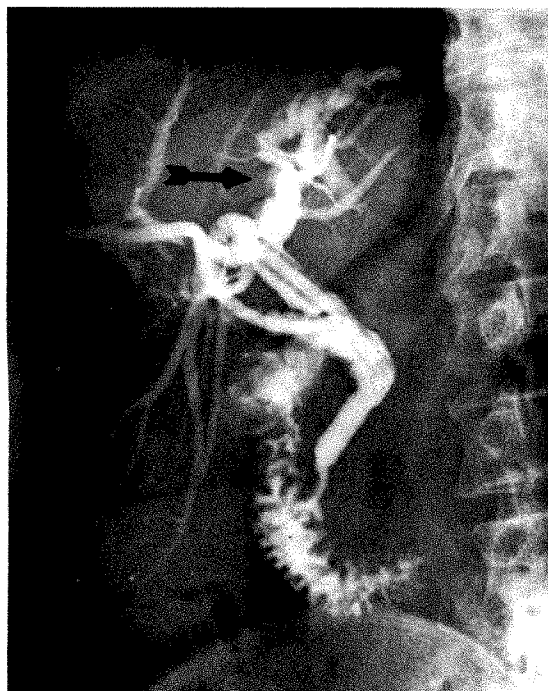


FIG. 10. T-tube cholangiogram, frontal projection. Occasionally, the left hepatic duct is seen to give off multiple small branches, a "centipede" configuration, representing a normal variant (arrow).

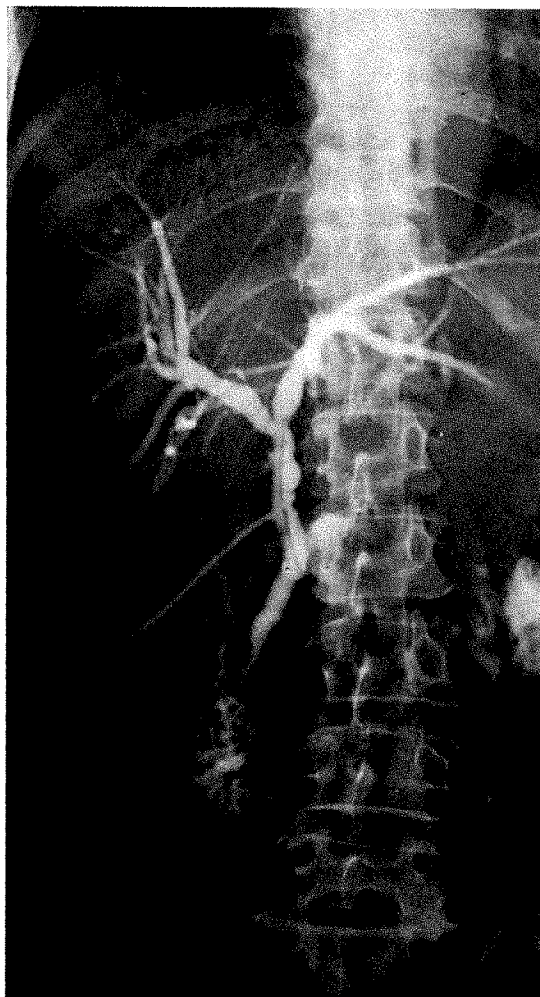


FIG. 11. T-tube cholangiogram, frontal projection. The left hepatic duct is seen to bifurcate into two branches of equal size, a normal variant.

parenchyma. In obstructive choledochopathy, the left hepatic duct is noted to be wider than the right, even though it supplies the smaller lobe of the liver (Fig. 8). Under such circumstances, the left hepatic duct may become extremely tortuous and dilated, a so-called "sigmoidization" (Fig. 9).

In hepatomegaly the left hepatic duct participates in the hypertrophy of the liver and its course may become deviated inferiorly, thus being an index of lobe size.

CYSTIC DUCT STUMPS

The lateral view is generally not required for roentgenographic evaluation

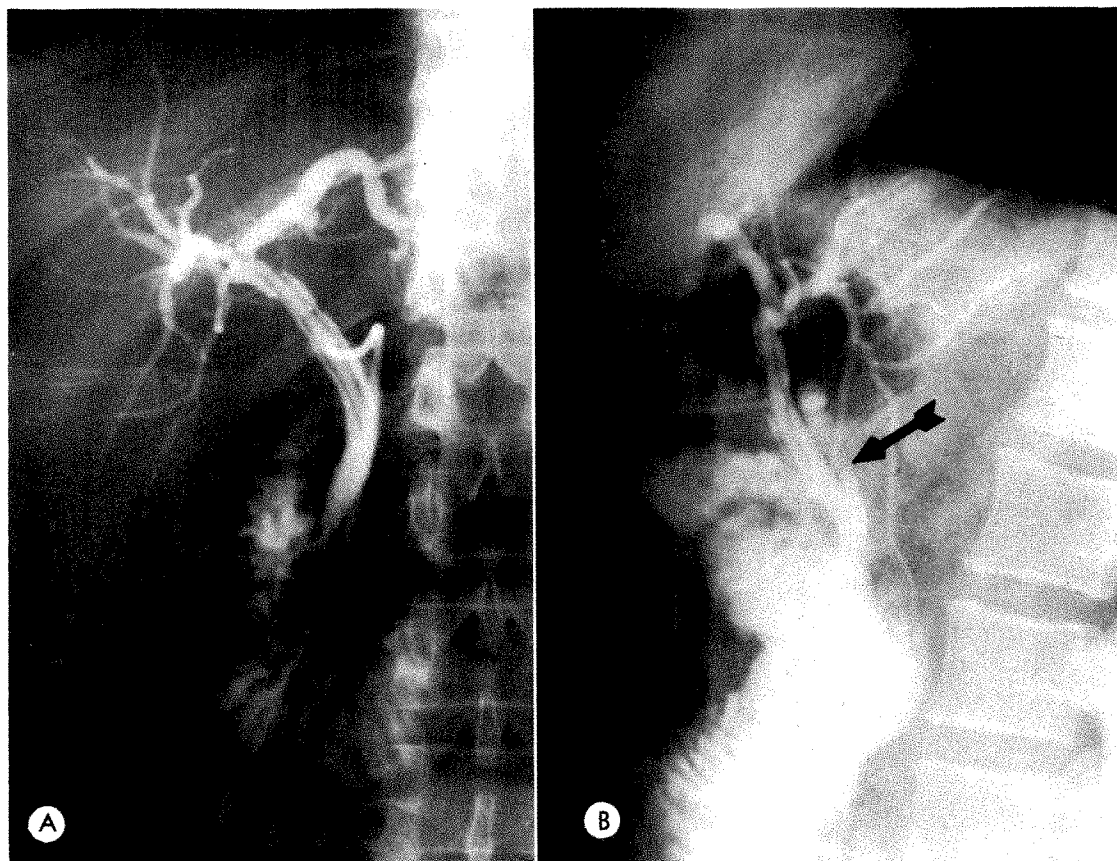


FIG. 12. T-tube cholangiograms, frontal (A) and lateral (B) projections. The arrow points to a long cystic duct stump, visible only in the lateral view. The cystic duct is parallel and posterior to the common duct.

of the common duct proper. However, the cystic duct may pursue a course parallel to the common duct, inserting into its distal portion. When this course is *posterior* to the common duct, the cystic duct will be recognized best, and sometimes *exclusively*, on the lateral projection. Such situations are illustrated in Figures 12, A and B and 13, A and B.

The correlation of roentgenographic and endoscopic findings in the hepatic ductal system is an important and interesting subject which will be dealt with in a separate report. Endoscopy has its primary application in the major hepatic ducts, while evaluation of the more peripheral structures remains predominantly a roentgenologic problem.

SUMMARY

Observations on the roentgenographic anatomy of the hepatic ductal system are presented, with particular emphasis on the lateral T-tube cholangiogram. The latter has been found to be of further value in the detection of cystic duct stumps.

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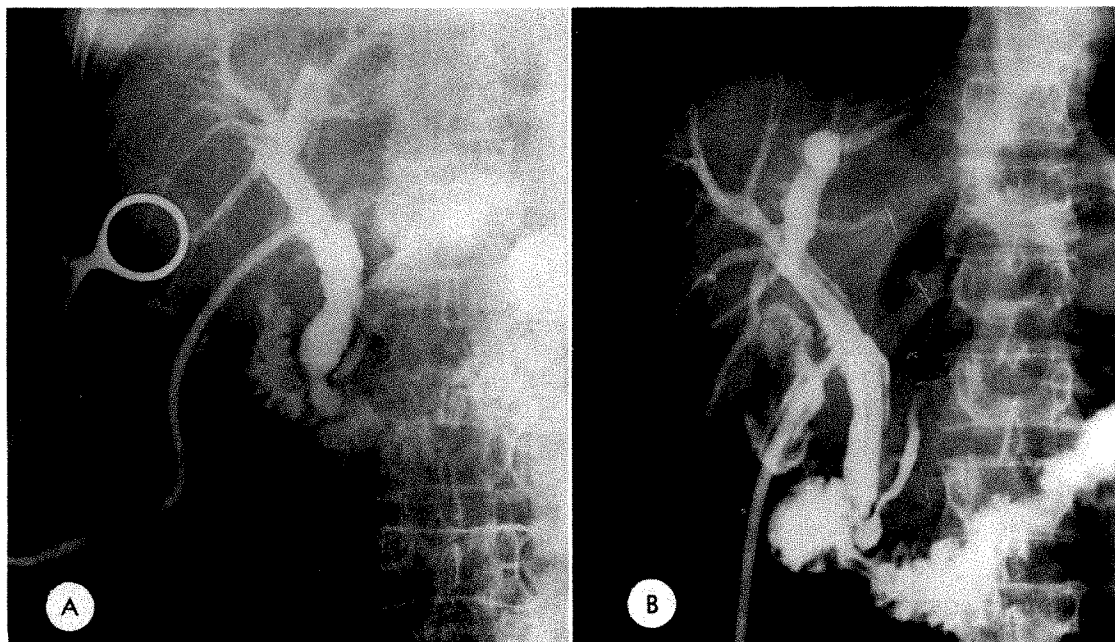


FIG. 1. (A and B) Postoperative T-tube cholangiograms. The choledocho-duodenal junction is at the angle formed by the second and third portion of the duodenum. In A the ampulla appears as a continuation of the common duct, in B as a part of the pancreatic duct.

12.5 cm. with an average of 10.16 cm., in "angle entries" from 8.5 to 15.0 cm. with a mean of 11.24 cm., and in "horizontal entries" from 9.8 to 14.3 cm. with an average of 12.11 cm.

It is, therefore, evident that in angle and horizontal entries the combined length of the hepatic and common ducts tends to be longer and the site of entry as related to the lumbar vertebrae is on a lower level.

Visualization of parts or the entire length of the main pancreatic duct was observed in 50 out of 122 cholangiograms (41 per cent); 40 times in patients with normal entry of the common duct, 5 times in 23 cases with angle entry and 5 times in 10 cases with horizontal entry. It is of interest to note that occasionally the pancreatic ducts were only visualized at a second cholangiographic examination and that sometimes, while they were filled at the first examination, they were not demonstrable at a second examination performed with the same technique. In 3 instances accessory pancreatic ducts were also demonstrated. Retained stones after explora-

tion of the common duct were demonstrated in 4 out of the 10 cases with horizontal entry. In angle entries this occurred in 5 out of the 23 cases, while in 89 cases with normal entry this was observed only 6 times.

DISCUSSION

The knowledge of the course of the common duct and its entry into the duodenum is of utmost importance to the surgeon who has to carry out a complete exploration of this part of the biliary tract.

Abnormalities in the course of the choledochus and a location of its entry into the duodenum unknown to the surgeon before exploration make the procedure inefficient and even dangerous. In our series of 122 cholangiograms an abnormal entry of the common duct was observed in 25.8 per cent. This high percentage was surprising since only scant reports on such an incidence were found in the anatomic or surgical literature.^{7,8,9}

A comparison of the results obtained by Lurje⁹ and by Kantor *et al.*⁸ and our series

TABLE I
LOCATION OF THE CHOLEDOCHAL ENTRY
INTO THE DUODENUM

	Lurje ⁹ 194 Autopsied Cases	Kantor <i>et al.</i> ⁸ 112 Cases	Authors' Series 122 Cases
Second part of duodenum	91.8%	96.6%	74.2%
Junction of second and third part of duo- denum: "angle entry"	—	2.6%	17.8%
Third portion of duodenum: "horizontal entry"	8.2%	0.8%	8.0%

is summarized in Table I.

The discrepancy between the results reported by these observers and ours can be

explained by the different roentgenographic techniques used. The cholangiograms analyzed in the present investigation were all obtained in strict anteroposterior position with a constant focus film distance of 3 feet, while Kantor *et al.*⁸ based their results in part on cholangiograms obtained in a not strictly anteroposterior position. Rotation of the body during the examination causes an overlap of the distal descending portion on the third portion of the duodenum. The autopsy findings of Lurje,⁹ with regard to the entry of the choledochus into the third portion of the duodenum are confirmed by our investigation performed in the living. It is likely that this author included the "angle entries" into the distal part of the descending duodenum.

Hicken and his associates⁷ studied the anatomic variations of the bile ducts by cholangiography and described the many-

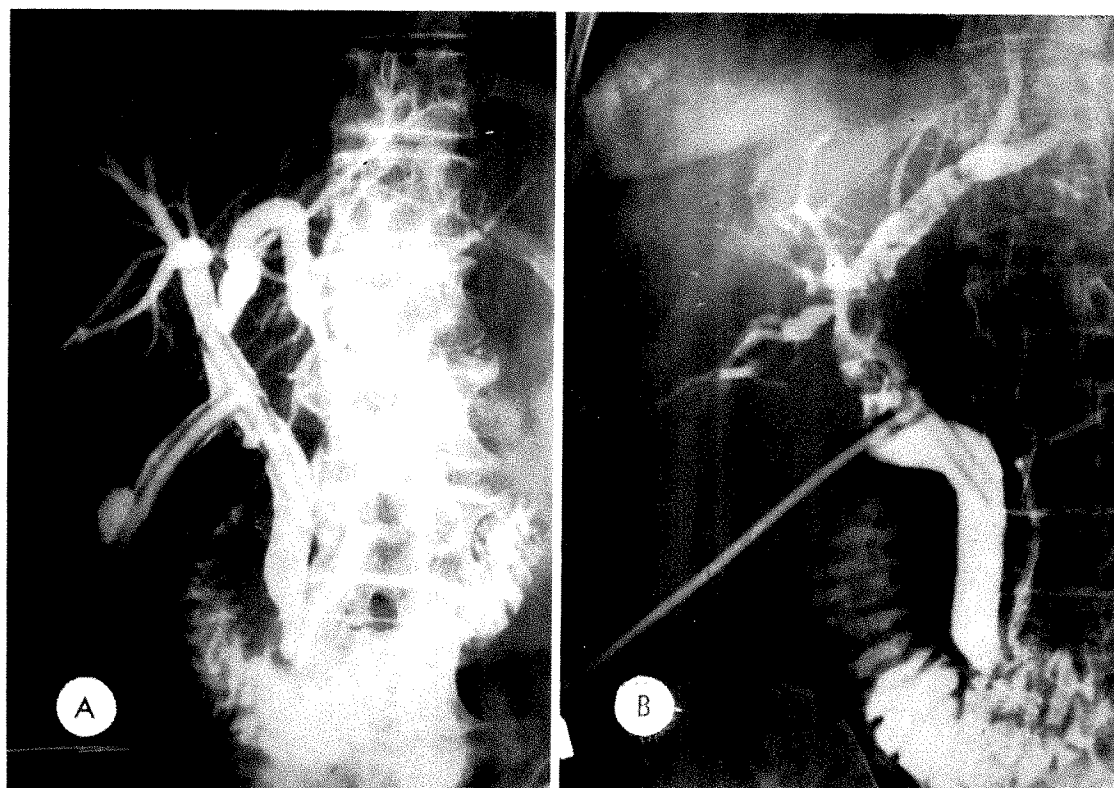


FIG. 2. (A and B) Postoperative T-tube cholangiograms. The common and pancreatic ducts enter into the third portion of the duodenum. Note the radiolucent faceted calculi in the common duct in A and the numerous similar filling defects in the left intrahepatic and common hepatic duct in B.

fold variations in the course and direction of the choledocho-duodenal junction. The cholangiograms reproduced in their publication reveal angle and horizontal entries as well. Buckstein⁸ mentions the variations in the position of the papilla of Vater and describes a case in which the common duct entered into the third portion of the duodenum.

In contrast to the relatively frequent occurrence of "angle" and "horizontal entries," a choledochal entry into the first portion of the duodenum seems to be extremely rare as can be deduced from the very few reports describing single cases. Such anomalies have been reported by Rosteck,¹¹ Dochez and Haber⁵ and have not been observed in our material.

The frequency of choledocholithiasis and of gallstones left behind after exploration with aberrant entries of the choledochus is striking. The highest incidence of choledocholithiasis (70 per cent) and of retained stones after exploration (40 per cent) was found in cases with an entry of the choledochus into the horizontal portion of the duodenum. The incidence of choledocholithiasis in "normal" and "angle entry" varied slightly (40-50 per cent). However, a three fold incidence of retained stones after exploration was found in the latter as compared with that of normal entry (6.7 per cent).

It is not possible to conclude from these

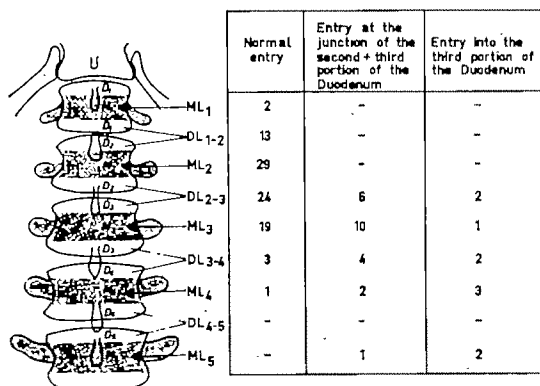


FIG. 3. Relation of the choledocho-duodenal junction to the lumbar spine at various sites of entry.

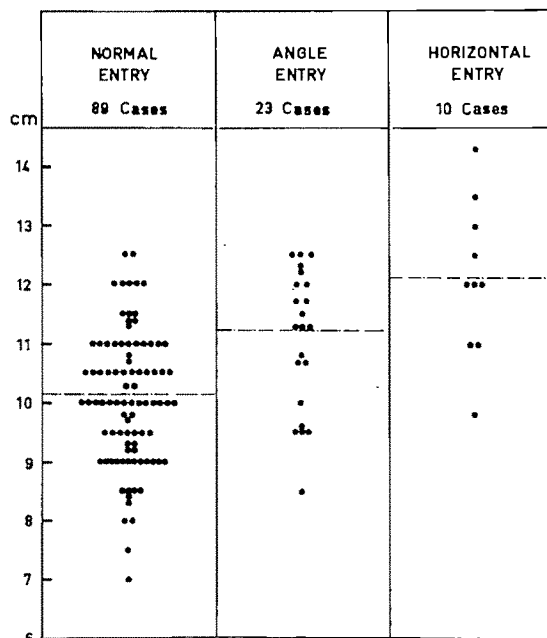


FIG. 4. Combined length of the hepatic and common duct at various sites of entry into the duodenum.

results whether an aberrant course and entry of the common duct favor choledocholithiasis; it is evident, however, that surgical exploration of the choledochus is less efficient in the presence of such anatomic deviations.

It may be argued that our results based on a selected group of patients suffering from gallstones are not representative for the true incidence of aberrant entry of the choledochus in the general population. This assumption, however, is unlikely in consideration of the similar results reported by Lurje⁹ in an unselected group of 162 adults and 32 children.

The frequent association of aberrant entry, choledocholithiasis and retained stones emphasizes the importance of operative cholangiography for a successful exploration and complete removal of stones from the common duct.

SUMMARY

The topography of the entry of the common bile duct into the duodenum was studied on 122 T-tube cholangiograms. In

25.8 per cent an aberrant entry of the common duct into the junction of the second and third portion or into the lower horizontal portion of the duodenum was observed.

In cases of abnormal entries the combined length of the hepatic and common duct was increased and the choledochoduodenal junction in relation to the lumbar spine was found at a lower level.

Choledocholithiasis and retained stones after exploration were found more frequently in patients with aberrant entries than in those with normal entry of the common duct into the duodenum.

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ROENTGENOLOGIC MANIFESTATIONS OF PRIMARY HEPATOMA WITH PARTICULAR REFERENCE TO SOME UNUSUAL CHOLECYSTOGRAPHIC FINDINGS*

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PRI-MARY hepatoma is seldom considered in the differential diagnosis of an upper abdominal mass, but in view of the increasing frequency of surgical resection for this lesion,^{1,4,5} diagnosis has become important. For this reason, the authors have analyzed the roentgenologic findings in a group of cases in order to assess the value of roentgenology in earlier diagnosis.

INCIDENCE

In the larger series of cases reported in the United States, the autopsy incidence of hepatoma ranged from 0.1 to 0.5 per cent.^{10, 18, 20, 29} The lesion is, however, more frequent in Asia and Africa where an incidence of 2 per cent and 5.6 per cent respectively has been reported.^{7, 28}

PATHOLOGY

Grossly, primary carcinoma of the liver assumes one of three forms.^{10, 18, 28} It may occur as a solitary tumor, predominantly in the right lobe of the liver, as multiple tumor nodules, or as an uncommon diffuse lesion.

Histologically, two main types are described. The hepatocellular type arising from the liver cells is the more common, one-third of these presenting as a solitary tumor. The cholangiocellular or bile-duct type is less frequent and usually occurs as multiple nodules or as the diffuse type of lesion.

Although intrahepatic spread of the lesion is common, extrahepatic metastasis also occurs, mainly to the lungs, but also to the skeleton, peritoneum and adrenals. In over 50 per cent of cases in the larger re-

ported series,^{10, 18, 32} primary carcinoma has been associated with cirrhosis of the liver.

CLINICAL MANIFESTATIONS

The most common presenting symptoms are vague indigestion, anorexia, upper abdominal discomfort or pain.^{3, 8, 20} Jaundice is found in 50 per cent of cases and ascites less frequently.

On physical examination there may be generalized or nodular hepatic enlargement, and in some cases a mass continuous with the liver may be palpable in the right upper quadrant.

The laboratory findings are nonspecific and include anemia, a raised erythrocyte sedimentation rate and impaired liver function tests, especially in those cases with an associated cirrhosis.

REVIEW OF LITERATURE

Although clinical reports make brief allusion to the roentgenologic findings such as displacement of the gastrointestinal tract or elevation of the right hemidiaphragm, only two articles deal specifically with the roentgenologic findings in hepatoma. Schatzki²⁴ emphasized that elevation of the right hemidiaphragm, associated with the demonstration of esophageal varices, should lead to the suspicion of primary hepatoma. Margulis *et al.*¹⁹ described the appearances presented in infants and children.

Incidental references to hepatoma or to hepatic masses, in general, are found in reports on special techniques. Stattin,²⁵ for instance, in an assessment of splenoportography which included 4 cases of hepatoma,

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concluded that the only reliable roentgenologic evidence of liver malignancy was the presence of filling defects when the liver was homogeneously opacified with contrast medium. The defects noted with primary hepatoma are usually larger than those found with metastatic lesions.²³ The use of laminagraphy combined with percutaneous splenoportography has been suggested to increase diagnostic accuracy.¹²

Translumbar aortography with the injection of contrast medium directly into the hepatic arteries and veins via catheter has also been used in the diagnosis of hepatic neoplasms.^{2,17,22} Displacement of vessels, pooling of contrast medium, increased vascularity in the region of the tumor and avascular defects have all been observed, but no specific findings relative to hepatoma have been noted.

Yet another approach to diagnosis has been the utilization of radioactive isotope uptake studies, particularly I^{131} rose bengal.^{9,14,33} Neoplasms are shown on the scintigram as areas of depressed activity with this isotope. These may be differentiated from unusual liver lobulations in that the latter show normal liver activity.¹³

From this review, it is clear that emphasis has been placed on the highly specialized techniques in the investigation of liver masses, and the simpler roentgenologic procedures such as gastrointestinal studies, urography and cholecystography have been neglected.

MATERIALS

During the period 1955 to 1960 in a 700 bed general hospital, 12 cases were found with histopathologic confirmation of primary carcinoma of the liver. The roentgenologic examinations available for study in these cases were analyzed.

ROENTGENOLOGIC FINDINGS

The roentgenologic findings in each of the 12 cases are summarized in Table 1.

Chest Roentgenograms. Eight of the 12 patients had chest roentgenograms. Five cases showed an elevation of the right

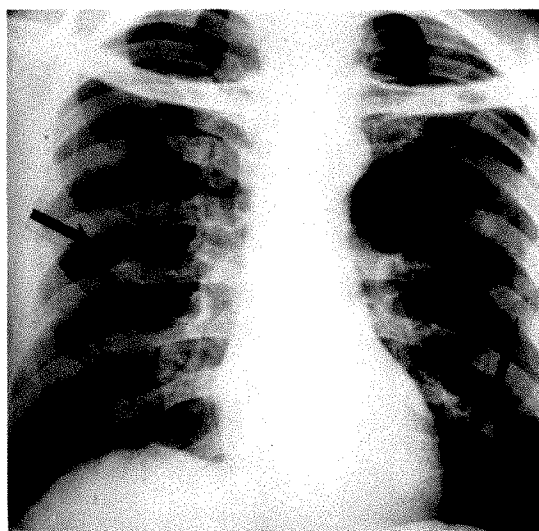


FIG. 1. Chest roentgenogram demonstrating elevation of the right hemidiaphragm 4 cm. above the left. Multiple tumor nodules are present throughout the lung fields. A large solitary hepatoma of the lateral aspect of the right lobe of the liver was found at autopsy.

hemidiaphragm (Fig. 1). Two demonstrated a localized bulge of the hemidiaphragm which, in one case, was correlated with autopsy findings of a large circumscribed tumor in the right lobe of the liver. Three cases showed metastatic rounded tumor nodules, ranging in size from 0.5 to 2 cm. in diameter.

Plain Roentgenogram of the Abdomen. Of 3 cases with plain roentgenograms of the abdomen, a marked general enlargement of the liver was demonstrated in one, while the other 2 cases showed a definite mass in the right upper quadrant, corresponding to a large solitary lesion in the right lobe of the liver (Fig. 2).

Gastrointestinal Examination. Eleven of the 12 cases had an upper gastrointestinal study. Eight showed displacement of the stomach to the left and/or extrinsic pressure defects on the antrum or body of the stomach (Fig. 3). Of 5 cases exhibiting antral deformity, 3 were predominantly due to involvement of the right lobe of the liver, while 2 had mainly left lobe involvement. In 9 of the 11 cases, there was evidence of extrinsic pressure on the duo-

TABLE I

SUMMARY OF ROENTGENOLOGIC FINDINGS IN 12 CASES OF PRIMARY HEPATOMA

Case No.	Chest Roentgenogram	Plain Abdominal Roent- genogram	Upper Gastrointestinal Roentgenogram	Barium Enema Examina- tion	Intravenous Pyelogram	Liver Scan	Cholecystogram	Gross Pathology
1. A.R. 45 F	Metastatic nodules; ele- vated right diaphragm	—	Extrinsic pres- sure on duode- num	Displaced hepatic flexure	—	—	Displacement and extrinsic pressure	Multiple nodules of entire liver
2. C.W. 55 M	—	—	Extrinsic pressure on antrum	Normal	—	—	—	Multiple nodules
3. M.B. 68 M	—	Mass in right upper quadrant	Extrinsic pres- sure on antrum, duodenum and jejunum	Displaced hepatic flexure	Normal	—	Displacement and extrinsic pressure	Large solitary right lobe lesion
4. B.H. 63 M	Metastatic nod- ules; elevated right diaphragm with local bulge	Mass in right upper quadrant	Extrinsic pres- sure on duode- num	Normal	—	—	Nonvisualized gallbladder	Large solitary right lobe lesion
5. B.N. 50 F	Elevated right diaphragm with local bulge	—	Extrinsic pres- sure on duode- num	Normal	—	—	Nonvisualized gallbladder	Multiple nodules
6. K.G. 67 M	Normal	—	Extrinsic pres- sure on antrum and duodenum	—	—	—	—	Multiple nodules
7. G.L. 59 M	Normal	—	Extrinsic pres- sure on antrum and duodenum	Normal	—	—	—	Large solitary left lobe lesion
8. A.B. 55 F	—	—	Extrinsic pres- sure on antrum	Displaced hepatic flexure	Normal	—	Displacement and extrinsic pressure	Tumor mass o entire right lobe
9. J.G. 66 M	Elevated right diaphragm	—	Displaced to left and extrinsic pressure on body of stomach and duodenum	Displaced transverse colon	—	Large area of de- pressed activity in left lobe	Nonvisualized gallbladder	Large left lobe lesion
10. G.W. 58 F	Metastatic nodules	—	—	—	—	—	—	Tumor mass of entire right lobe
11. M.S. 60 F	Elevated right diaphragm	—	Displaced to left and extrin- sic pressure on duodenum	Displaced hepatic flexure	—	—	—	Multiple nod- ules of right lobe
12. W.S. 59 M	—	Very large liver	Extrinsic pres- sure on antrum and duodenum	Displaced hepatic flexure	—	—	Initial study: displacement and extrinsic pressure noted on decubitus roentgenogram; later study: small irregular collection of medium in gallbladder	Multiple nod- ules of entire liver; gross infiltration of gallbladder



FIG. 2. Roentgenogram from a small bowel study. The outline of a mass arising from the inferior surface of the liver is indicated by the arrows. Encroachment on a loop of small bowel is also demonstrated.

denum. This consisted of an extrinsic defect on the superior aspect of the duodenal bulb (Fig. 4), flattening of the outer margin of the duodenal loop, or an actual concave defect in the margin of the loop (Fig. 5 and 6).

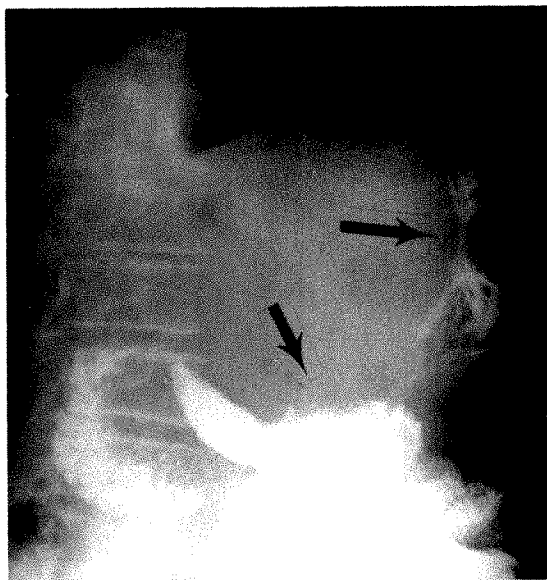


FIG. 3. Upper gastrointestinal roentgenogram demonstrating considerable extrinsic pressure on the body and antrum of the stomach (arrows) by a large solitary left lobe lesion.

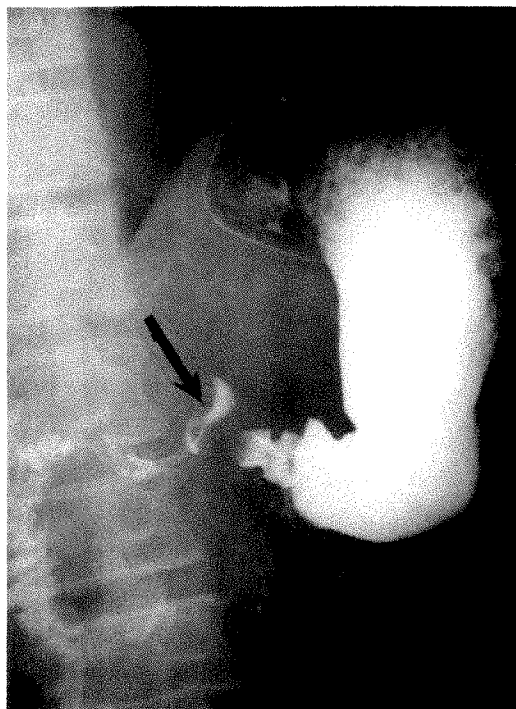


FIG. 4. The arrow indicates the area of extrinsic pressure on the superior aspect of the duodenal bulb. The gallbladder had been removed surgically many years previously. Necropsy revealed a liver studded with tumor nodules and weighing 4,000 gm.

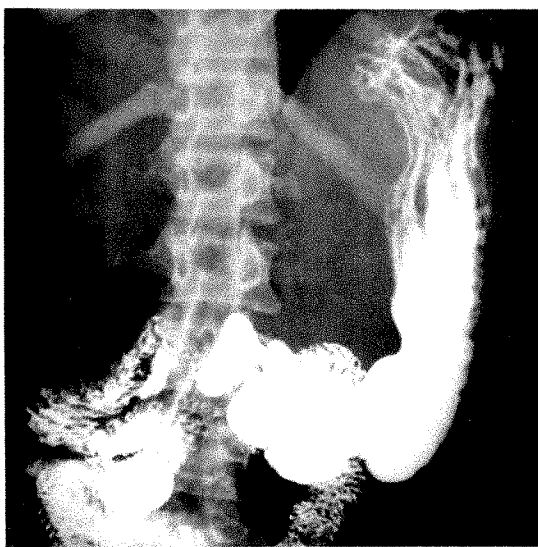


FIG. 5. Concavity of the outer margin of the duodenal loop is indicated by the arrow. Autopsy in this case revealed multiple tumor nodules throughout an enlarged liver.

In one case, a small bowel study demonstrated encroachment on a loop of jejunum by a mass in the right upper quadrant (Fig. 2).

Barium Enema Examination. Of 10 cases having this examination, inferior displacement of the hepatic flexure was demonstrated in 5, 3 of these showing predominant involvement of the right lobe of the liver at autopsy. One case showed depression of the entire transverse colon (Fig. 7). The remaining 4 cases showed no abnormality of the colon.

Intravenous Urography. Two cases had intravenous urography and these showed no significant abnormality.

Radioisotope Studies. One case had a liver scintigram performed with I^{131} rose bengal. A large area of depressed activity, corresponding to a solitary left lobe lesion, was demonstrated (Fig. 8).

Cholecystography. Oral cholecystography was performed in 7 cases. In 3 of these cases there was nonvisualization of the gallbladder and biliary tract, although only one of these patients was jaundiced. In the

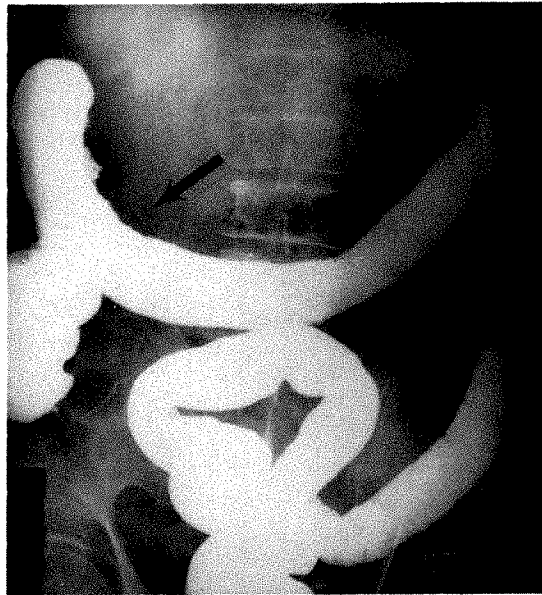


FIG. 7. Roentgenogram from a barium enema examination demonstrating downward displacement of the transverse colon. This is the same case demonstrated in Figure 3.

remaining 4 cases, the findings were unusual and will be described in detail.

CASE 1. A forty-five year old female gave a three month history of generalized abdominal



FIG. 6. This case also demonstrates extrinsic pressure on the outer margin of the duodenal loop (arrow) and in addition there is extrinsic pressure on the antrum of the stomach. The liver was markedly enlarged and multiple tumor nodules were present throughout at autopsy.

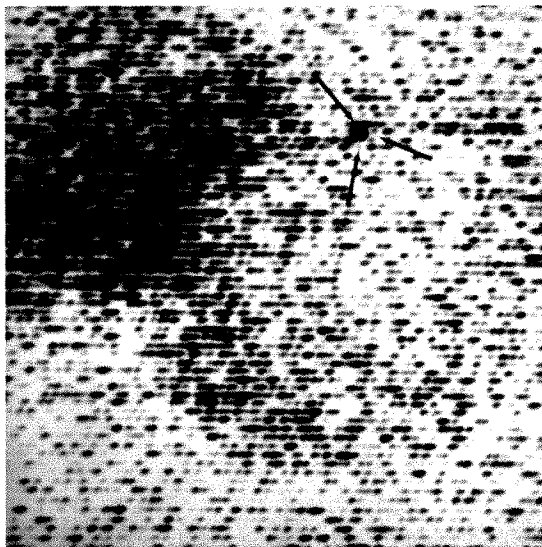


FIG. 8. Hepatic photoscintigram demonstrating a large area of depressed activity in the region of the left lobe, corresponding clinically to a large epigastric mass. The arrows indicate a marker on the xiphoid process.

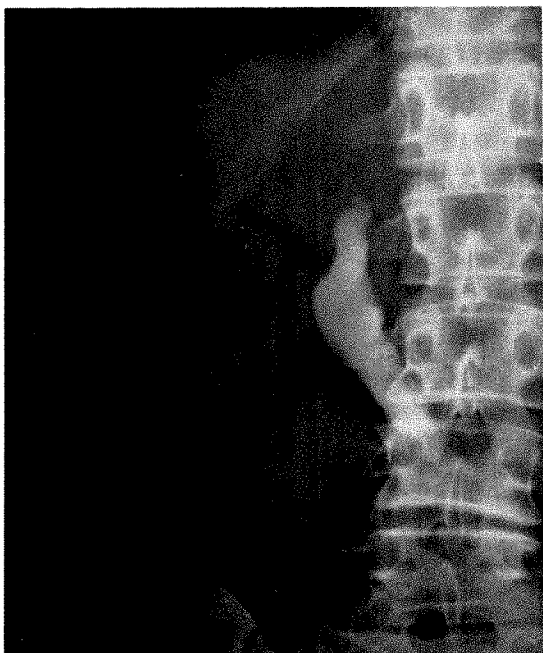


FIG. 9. Prone roentgenogram from the cholecystogram in Case 1. The medial displacement of the gallbladder is demonstrated. The arrow indicates an area of extrinsic pressure on the gallbladder.

pain and intolerance to fatty food, but there was no weight loss or jaundice. Physical examination disclosed a firm, slightly tender mass, 4 cm. in diameter, in the epigastrium. Cholecystograms showed good concentration of the contrast medium by the gallbladder, which appeared elongated and was displaced downwards and medially so that, in the prone position, the shadow overlaid the bodies of the third and fourth lumbar vertebrae (Fig. 9). A smooth concave defect measuring 3 cm. in length was noted on the lateral aspect of the neck of the gallbladder. A roentgenogram in the lateral decubitus projection accentuated the defect and the gallbladder maintained its medial displacement. Operation revealed moderate enlargement of the liver which was studded with varying sized tumor nodules.

CASE 3. A sixty-eight year old male gave a four month history of right upper quadrant pain associated with weight loss, but no jaundice. Physical examination revealed gross hepatic enlargement. Oral cholecystograms showed good concentration of the contrast medium. The gallbladder was almost horizontal in position and displaced laterally (Fig. 10). A

large, smooth concave defect 8 cm. in length, was present on its inferior aspect. A lateral decubitus roentgenogram showed no change in the position or configuration of the gallbladder. At surgery, a large tumor arising from the anterior surface of the liver extending in an inferior and medial direction was found.

CASE 8. A fifty-five year old female was investigated, one year before her final admission, for a questionable right upper quadrant mass, but no abnormal findings were detected. She returned, complaining of right upper quadrant pain, and physical examination revealed a definite firm mass, thought to be separate from the liver. Cholecystograms demonstrated good concentration of the contrast medium by the gallbladder. The gallbladder appeared elongated, and was displaced inferiorly, the fundus lying at the level of the right transverse process of L5, in the prone position (Fig. 11). The lateral margin of the gallbladder presented a scalloped appearance from 3 rather large, smooth concave defects. Again, the lateral

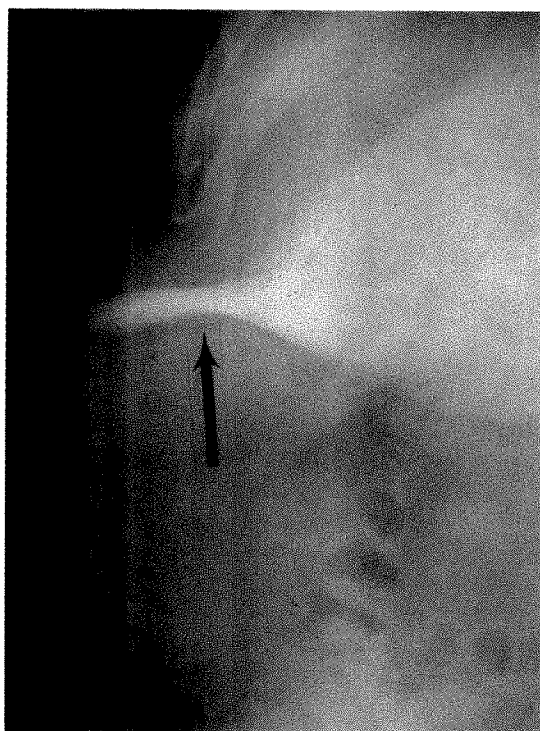


FIG. 10. Case 3. The marked lateral and upward displacement of the gallbladder is shown. The arrow indicates the large extrinsic pressure defect on the inferior surface.

decubitus position accentuated the defects and showed the gallbladder to be fixed in its abnormal position. Operation revealed a tumor occupying the entire right lobe of the liver, with a small nodule present in the left lobe.

CASE 12. A fifty-nine year old male complaining of headache and upper abdominal pain had extensive investigation, including cholecystography. The position and contour of the gallbladder appeared essentially normal in the prone position, but in the lateral decubitus, the gallbladder showed no mobility and a smooth shallow concave defect was noted on the dependent portion. Three months later the patient was admitted to the hospital with anorexia, abdominal pain and weight loss. At this time, a firm grossly enlarged liver was palpable. Cholecystograms showed a small irregular collection of contrast medium in the gallbladder, which presented the same configuration in all positions. Autopsy revealed multiple tumor nodules in the liver, with tumor infiltration of the gallbladder. The latter probably accounted for the bizarre cholecystographic findings on the second examination.

DISCUSSION

Although there are no specific roentgenologic features from which a diagnosis of primary hepatoma may be made, the present series emphasizes certain findings that may be helpful in enabling the radiologist to suggest the possibility of the lesion.

Schatzki²⁴ observed that elevation of the right hemidiaphragm, if associated with esophageal varices, should lead to suspicion of hepatoma. In our series, esophageal varices, though not specifically sought, were not demonstrated in any of the cases. Elevation of the right hemidiaphragm, however, was found in 5 of 8 cases having chest roentgenograms, and 2 of these showed a localized bulge on the diaphragm. The bulge appeared as a discrete, smooth elevation in the lateral part of the hemidiaphragm, thus differentiating it from scalloping, which usually shows several undulations in the anteromedial part of the hemidiaphragm.

Epstein,¹¹ in his kymographic study of the diaphragm in hepatic neoplasms, considered that as the right hemidiaphragm-

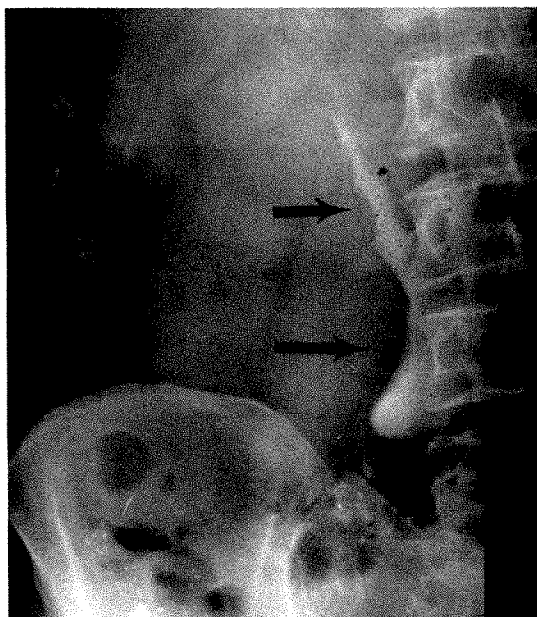


FIG. 11. Cholecystogram from Case 8 demonstrating medial displacement of the gallbladder and multiple extrinsic pressure defects (arrows).

matic level was normally higher than the left, a difference of level of 2.5 cm. was evidence of elevation and this criterion was used in the present series.

Roentgenograms of the abdomen revealed either generalized hepatic enlargement or a mass in the right upper quadrant, confluent with the liver. In infants and children, an undulating inferior margin to the liver is said to be more typical of hepatoma than of hepatic cyst.¹⁹

Although Wallace³¹ reported a case showing calcification in a large solitary hepatoma of the right lobe of the liver in an adult, calcification is more frequently found in hepatomas in childhood.^{19,30} None of our cases showed calcification in the lesion.

Gastrointestinal studies may, apart from excluding an intrinsic lesion, give findings relative to the mass itself. In our cases, in general, hepatic enlargement or predominant involvement of the left lobe displaced the stomach to the left, while lesions of the right lobe and those projecting from the inferior margin of the liver caused extrinsic

pressure defects on the lesser curvature and on the antrum of the stomach.

The duodenum, being relatively fixed in position, rarely showed displacement, but extrinsic pressure on the duodenal bulb and loop was a frequent finding. Encroachment on the junction of the first and second parts of the duodenum or a concave impression on the lateral aspect of the second part of duodenum was especially common.

Extrinsic pressure defects on the stomach or duodenum occurred in the majority of our cases, and it is suggested that such defects should not be too readily assumed to be due to spleen, gallbladder, or anomalous liver lobes.

Barium enema examination demonstrated inferior displacement of the hepatic flexure, particularly in right lobe lesions. Inferior displacement of the entire transverse colon was observed in one case with a large hepatoma in the left lobe.

Intravenous urography disclosed no abnormality, though it was performed in only 2 cases. It has proved more useful in children, however, especially in excluding Wilms' tumor and neuroblastoma which are the more important differential diagnoses.¹⁹ Tumors of the right lobe of the liver may cause inferior displacement of the right kidney, while those of the left lobe may produce inferior and posterior displacement of the left kidney.

Oral cholecystography in our cases provided the most interesting and unusual findings. The examination has been performed infrequently in cases of primary hepatoma, possibly because many of these patients are jaundiced when first seen. When mention of the examination has been made in the reported cases, the results have been recorded as normal or as nonvisualization of the gallbladder.

Cases 1, 3, and 8 showed large, smooth regular indentations on the gallbladder contour. Because no direct extension of tumor tissue to the gallbladder could be demonstrated, it must be assumed that these indentations were on the basis of extrinsic pressure. Two of the 3 cases showed good correlation between the soli-

tary nature and localization of the lesion, on the one hand, and the cholecystographic findings on the other.

Case 12 showed a small extrinsic impression on the gallbladder at the first examination but subsequently a filling defect in the center of the gallbladder shadow was demonstrated. The appearances at this second examination were correlated with the autopsy findings of hepatoma tissue invading the lumen of the gallbladder.

The value of the lateral decubitus roentgenogram is emphasized as demonstrated fixation of the gallbladder and in all cases accentuated the extrinsic defect. In fact, in Case 12 this projection was the only one that demonstrated the defect.

Reports of either extrinsic or intrinsic defects in the gallbladder are rare. Buckstein⁶ states that an irregularity of the contour of the gallbladder on cholecystograms may occur with primary carcinoma of the gallbladder, and a reproduction of a roentgenogram is shown as evidence, demonstrating grossly irregular filling defects in the contrast medium. A similar illustration representing a gallbladder carcinoma is found in a report by Taterka.²⁸

As the appearances in Case 12 at the second examination resembled those described by both Buckstein and Taterka, it is clear that the cholecystographic findings in primary carcinoma of the gallbladder and in primary hepatoma may be identical, but only when the latter has invaded the lumen of the gallbladder. It is stressed in recent series that in the majority of gallbladder carcinomas, the gallbladder fails to visualize on cholecystograms.^{12,21,27}

Regarding extrinsic pressure defects, Geist¹⁶ cites 2 cases of nonparasitic liver cysts, the cholecystogram in one of these demonstrating superior and medial displacement of the gallbladder, together with indentations on the contour of the gallbladder.

A more recent report by Gambill and Hodgson¹⁵ describes extrinsic pressure defects on the gallbladder due to polycystic disease of the liver.

Although extrinsic defects would be

expected to occur from any mass lesion in the liver, at present they have been described only in hepatic cysts, and, in this series, in hepatoma. Clinical differentiation of these two lesions is usually not difficult, as cysts, unlike hepatoma, are associated with mild symptoms and jaundice is rare. Cholecystography then would appear to be of value if hepatoma is suspected in the nonjaundiced patient.

In conclusion, it is contended that, as the clinical features and laboratory aids are nonspecific in hepatoma, radiology may play an important role in the earlier diagnosis. Elevation of the diaphragm, extrinsic defects on the gastrointestinal tract, and particularly the presence of indentations on a fixed or displaced gallbladder should be carefully evaluated if the diagnosis of hepatoma is not to be overlooked.

SUMMARY

1. The roentgenologic findings in a series of 12 cases of primary hepatoma have been analyzed and the literature reviewed.

2. Elevation of the right hemidiaphragm and extrinsic defects of the gastrointestinal tract occurred in the majority of cases.

3. Cholecystography demonstrated in 4 cases extrinsic pressure defects on a fixed gallbladder. The value of the lateral decubitus projection in accentuating the defects is stressed. Similar appearances have been described only in connection with intrahepatic cysts, which are easily differentiated clinically, from hepatoma.

Late in the disease, one case produced cholecystographic appearances indistinguishable from carcinoma of the gallbladder.

4. On the basis of this analysis, roentgenology and, in particular, cholecystography are considered to be valuable adjuncts in the earlier diagnosis of hepatoma in the nonjaundiced patient.

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THE AMERICAN JOURNAL OF ROENTGENOLOGY, RADIUM THERAPY AND NUCLEAR MEDICINE

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Forty-fourth Annual Meeting: Waldorf-Astoria Hotel, New York, N. Y., April 2-4, 1962.

* *Ex officio.*

A EDITORIALS A

POLYPOID LESIONS OF THE GALLBLADDER

CHOLECYSTOGRAPHY is one of the most widely used, most reliable, and safest of the special diagnostic procedures employed by the roentgenologist. Upon being introduced into clinical practice in 1925, it gained immediate favor and now has achieved universal acceptance. This is understandable when cholecystography is considered in relation to the frequency and importance of cholecystic disease. As an acute abdominal disorder of surgical significance and as a source of chronic digestive symptoms, inflammatory disease of the gallbladder is one of the commoner problems facing the medical practitioner. The gallbladder apparently causes so much disability in so many persons that an examination which can reliably identify the presence of gallstones is extremely valuable. It is comprehensible, therefore, that interest in a rarer group of lesions of the gallbladder was slower to develop. In the last few years, however, identification of polypoid lesions of the gallbladder has become more common.

The epithelial lining of the lumen of various parts of the alimentary tract gives rise to a variety of polypoid lesions. It is not surprising that this should also be true in the gallbladder, which originates as an outgrowth from the primitive gut. The genesis of mucosal neoplasms is no more evident in the gallbladder than elsewhere. The variety of cholecystic lesions that may develop is just as great as in other mucosal passages that are derived from the primitive gut. In addition, since the gallbladder is peculiarly the site of storage and concentration of a cholesterol-containing liquid, the macrophages in the gallbladder wall have a unique opportunity to "take up" cholesterol products. This they do in fact, and, depending on the number, location and activity of

the macrophages, various types of cholesterol depositions may be manifest. These may vary from scattered, yellowish flakes in the mucosa ("cholesterolosis" or "strawberry" gallbladder) to much larger collections which can develop as single, smooth projections or complex, nodular or mulberry-like, cholesterol polyps.

The term, "polyp," has led to as much confusion in terminology in cholecystic lesions as it has in those of the colon. Surgeons and proctologists, as well as roentgenologists, have used the term to indicate any polypoid structure that can be identified grossly. Some have used the word to convey a connotation of relatively small or relatively innocuous appearance, as compared with a larger growth that might be grossly described as a fungating or polypoid tumor. Pathologically, however, justification for the connotation of benignancy in using the simple term, polyp, may be open to question. Microscopically, it has been necessary to add an adjective—inflammatory, adenomatous, or carcinomatous—to indicate the histologic nature of the polyp. In the gallbladder, one has the additional confusion of still another entity—the polypoid mucosal structure laden with cholesterol.

The basic pathologic polypoid lesions in the gallbladder include cholesterol polyp, inflammatory polyp, polypoid adenoma and polypoid carcinoma. The characteristic structure of each may be defined simply. A cholesterol polyp is a greatly enlarged, villous-like structure, covered with a single epithelial layer and largely filled with macrophages laden with cholesterol esters. An inflammatory polyp is a projecting mound of inflammatory tissue, usually sessile, generally associated with advanced chronic cholecystitis and showing no par-

ticular cholesterol deposition or glandular structure. Associated Aschoff-Rokitansky sinuses, with or without intramural calculi, may make the microscopic appearance more complex. A polypoid adenoma is a true neoplastic structure—composed of glandular elements and a vascular connective tissue stalk which arises from the mucosa in sessile or pedunculated fashion. The two characteristic types are glandular adenoma, with a relatively smooth mucosal surface, or papillary adenoma with a mucosal surface containing delicate, finger-like projections. This latter type of adenoma is sometimes referred to as a papilloma. The distinction between glandular and papillary adenomas of the gallbladder can be made only on microscopic appraisal. Gross appraisal of the adenoma does not permit classification of the structure into glandular or papillary varieties, nor does it always permit identification of carcinomatous polyps. Noninvasive carcinoma, or carcinoma *in situ*, may be present in both types of polypoid adenomas. Polypoid adenocarcinoma has rarely been identified as a small lesion but exists as one of the diagnostic possibilities when one is confronted with a fixed radiolucent shadow in the gallbladder. Adenomyoma of the gallbladder develops as a mass of glandular and smooth muscle elements in an intramural location, rarely has a polypoid intra-

luminal projection, but in a contracted gallbladder may produce a heaping up of fundal mucosa in such a way as to mimic an epithelial growth. Even rarer tumors, such as fibroadenoma, neurinoma, and vascular lesions, have been described.

One practical problem that confronts the roentgenologist is selection of a diagnostic term to apply to the radiolucent shadow in the gallbladder. If it remains in a fixed position, despite changes in the position of the patient, the diagnostic possibility of mucosal lesion rather than stone must be considered. Adenomas may be multiple but as the number of fixed shadows increases, the likelihood of cholesterol polyps increases. A marginal notch in the outline of the mucosa, when the lesion is seen in profile, favors the diagnosis of adenoma rather than cholesterol polyp, as adenomas are more frequently sessile. In view of the multiplicity of lesions that may produce a small fixed, radiolucent shadow in the gallbladder, it would seem wise for the roentgenologist to label this shadow as "polypoid lesion of the gallbladder," until the specific microscopic structure is identified by pathologic examination.

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FRED M. HODGES

1887-1961

FRED M. HODGES was born October 31, 1887, in Linden, North Carolina. Following his preliminary training in local schools, he attended the University of Georgia, the Medical College of Virginia, and the University of Pennsylvania School of Medicine. Upon graduation in 1910, Dr.

Hodges came to Richmond, Virginia, and for two years engaged in the practice of general medicine. The then new specialty of radiology attracted his attention and he went to Vienna to take special training under Holzknect and Haudek. He returned to Richmond and specialized in the prac-

ice of radiology until World War I, when he joined the U. S. Army Base Hospital 45 and remained with this unit in Europe until he was appointed chief radiologist to the Justice Group of Hospitals in the Toule area.

After World War I, Dr. Hodges again returned to Richmond where he practiced, taught and became a leader in civic as well as medical affairs. Dr. Hodges was President of the Richmond Academy of Medicine in 1924, The American Roentgen Ray Society in 1935, the Southern Medical Association in 1936 and the American College of Radiology in 1939. For his original work in roentgen diagnosis and

therapy, he was widely recognized.

Although a busy physician, Dr. Hodges' interests were not limited to his profession. He liked sports and gardening. His humanitarian spirit was exemplified in his enthusiasm in organizing and counseling the Gambles Hill Community Center in its work for underprivileged children. His life was a model of a balance of humility, modesty, wisdom and courage.

Dr. Hodges died at his home October 24, 1961. He is survived by his wife, the former Louise Anderson, and their two children, Mrs. Walter Major and Fred M. Hodges, Jr.

HUNTER B. FRISCHKORN, M.D.



NEWS ITEMS

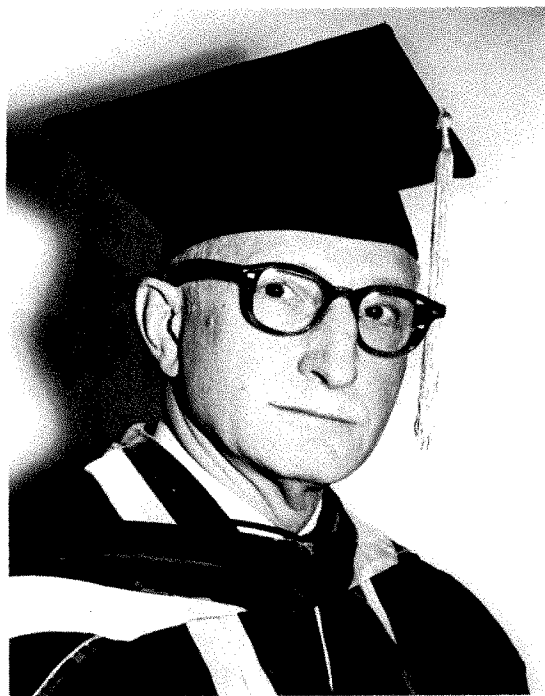
AMERICAN COLLEGE OF RADIOLOGY AWARDS GOLD MEDALS

The Convocation Ceremonies of the Thirty-eighth Annual Meeting of the American College of Radiology were held at the Roosevelt Hotel, New York City, on February 9, 1962. At these ceremonies Dr. L. H. Garland, President, conferred the degree of Fellow on 104 candidates and the degree of Associate Fellowship on 3 candidates who have been approved by the Board of Chancellors and elected by vote of the Fellows.

At the same ceremonies Dr. Garland presented two Gold Medals, the highest award of the College, "for distinguished and extraordinary service to the College and to the profession for which it stands." The recipients of this great honor were Dr. Earl E. Barth of Chicago, Illinois and Dr. Howard P. Doub of Detroit, Michigan.

OFFICERS OF THE AMERICAN COLLEGE OF RADIOLOGY

At the Thirty-eighth Annual Meeting of the American College of Radiology held at the Roosevelt Hotel, New York City, on February 7-10, 1962 the following officers were elected: President, Dr. Arthur J. Present, Tucson, Arizona; Vice-President, Dr. John Day Peake, Mobile, Alabama; Secretary-Treasurer, Dr. Fay H. Squire, Chicago, Illinois (re-elected); Chairman, Board of Chancellors, Dr. Theodore J. Wachowski, Wheaton, Illinois. Dr. Robert P. Barden, Philadelphia, Pennsylvania, and Dr. Jackson E. Livesay, Flint, Michigan, were elected to the Board of Chancellors. Dr. Edward Archibald Petrie, St. John, New Brunswick was re-nominated to the Board of Chancellors as a representative of the Canadian Association of Radiologists.



EARL E. BARTH, M.D.
Gold Medalist of the American College of
Radiology, 1962



HOWARD P. DOUB, M.D.
Gold Medalist of the American College of
Radiology, 1962

The Executive Director of the American College of Radiology is William C. Strohach, 20 North Wacker Drive, Chicago 6, Illinois, and the Director of Public Relations is Otha W. Linton, Chicago, Illinois.

The next Annual Meeting of the College will be at the Drake Hotel, Chicago, Illinois, February 6-9, 1963.

HISTORY AND MUSEUM OF RADIOLOGY IN THE UNITED STATES

The American College of Radiology has appointed an Ad Hoc Committee to (1) survey the proposal and suggest a protocol to produce a "History of Radiology in the United States," and (2) suggest a method for developing a "Museum of United States Radiology."

The Committee has received valuable guide lines from Dr. L. H. Garland, President of the College, and Dr. T. J. Wachowski, Chairman of the Board of Chancellors.

The Committee has knowledge of the continuing work of the "Gas Tube Gang," directed by Dr. E. C. Ernst of St. Louis, along parallel purposes and objectives. There has been an exchange of ideas and mutual cooperation.

The Committee also has knowledge of work progressing on the radiologic histories of some of the states and biographies of some of the martyrs.

The Committee is most anxious now to learn quickly about material and ideas that have not been organized or declared from those who have pertinent knowledge and interest.

Accordingly, early communications are gratefully invited on these and related matters, to help the Committee draft a final report.

The members of the Committee are: L. G. Idstrom, M.D., Minneapolis, Minn.; L. Etter, M.D., Warrendale, Penna.; E. R. N. Grigg, M.D., Champaign, Ill.; and M. H. Poppel, M.D., Chairman, 550 First Avenue, New York 16, N. Y.

COURSE IN RADIOLOGICAL PHYSICS

A one year course in radiological physics, leading to the degree of Master of Science,

is offered under the auspices of the Department of Radiology of the College of Physicians and Surgeons of Columbia University. It is designed to prepare candidates to carry out all the functions of a physicist in a hospital department of radiology; it would also furnish a foundation for those who wish to engage in research or applications in radiological physics, radiation protection, and dosimetry. The course includes lectures, seminars, conferences, and laboratory work. Topics included are elementary and advanced radiological physics, electronics, radiation standardization and protection, radioactive isotopes, biostatistics, radiobiology, instrument design, public health practice, health physics, and clinical applications of radiation physics. Prerequisite for admission is a bachelor's degree with a major or strong minor in physics, or equivalent scholastic background, and a good academic record. A knowledge of general chemistry and general biology is very desirable.

As part of its national program for the training of radiological health specialists, the Division of Radiological Health, Public Health Service, has awarded a grant to the University enabling financial assistance to qualified candidates. This aid will be in the form of tuition waiver as well as monthly stipend allowances. Applicants must be citizens of the United States or have filed a Declaration of Intent. Preference will be given to candidates who are sponsored by public health agencies for work in their area of responsibility or in closely related fields.

Inquiries should be addressed to Dr. W. Gross, 630 W. 168th Street, New York 32, New York.

CONFERENCE ON RADIOISOTOPE APPLICATIONS AND TESTS OF KIDNEY FUNCTION

A "Conference on Radioisotope Applications and Tests of Kidney Function" will be held May 25-26, 1962, sponsored by the Ohio State University College of Medicine, Postgraduate Department.

The subjects include the latest procedures, techniques and results of: The Radioisotope Renogram, Surgical Renography, The Radioisotope Renal Clearance Test, The Radioisotope Blood Clearance Test, The Radioisotope Vesical Residual Test, The Radioisotope Vesical-ureteral Residual Test and Tape Recording, Logarithmic and Linear Rate Meter Applications.

A distinguished Faculty will participate in the Conference. The registration free is \$20.00.

The meeting will be held in the Ohio Union on the Ohio State University Campus and the Center for Postgraduate Medical Education may be contacted for further information.

CONFERENCE ON PROGRESS IN NUCLEAR EDUCATION—SCIENCE AND ENGINEERING

A special Conference on "Progress in Nuclear Education—Science and Engineering" will be held in Gatlinburg, Tennessee, August 20-22, 1962.

The Conference is being sponsored by the American Nuclear Society, Oak Ridge National Laboratory, and the Oak Ridge Institute of Nuclear Studies, in cooperation with the U. S. Atomic Energy Commission. This 1962 Gatlinburg Conference is the latest in a series, sponsored since 1947 by ORNL and ORINS, devoted to the problems of education in the field of nuclear energy. The 1961 Conference was concerned with the subject of subcritical nuclear assemblies at universities and colleges, and in 1960 the conference topic was "University Reactors."

The invited papers to be presented in

this year's program will be devoted not only to the status and evaluation of nuclear-education programs at the college graduate and undergraduate level, but also to advances in secondary-school science education.

As in the previous conferences, outstanding educators, scientists, and administrators from institutions concerned with the problems of nuclear education will be featured on the program. Panel discussions and individual group discussions will also play an important part in the meeting.

Information about the conference may be obtained from the University Relations Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tennessee.

SYMPOSIUM ON BIOLOGY OF TRANSURANIC ELEMENTS

A symposium on the "Biology of the Transuranic Elements," sponsored by the U. S. Atomic Energy Commission will be held at the Commission's Hanford Laboratories in Richland, Washington, May 28-30, 1962. For information write to Dr. R. C. Thompson, Biology Laboratory, Hanford Laboratories, General Electric Company, Richland, Washington.

SEGUNDO CONGRESO NACIONAL DE RADIOLOGIA

The second Mexican National Congress of Radiology will be held in Guadalajara, México, April 8-12, 1962. A cordial invitation is extended to all radiologists.

Dr. Manuel Riebeling, *President*; Dr. Roberto Arroyo, *Secretary General*, Av. Avila Camacho 1303, Guadalajara, Jal., México.



BOOKS RECEIVED

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

RADIATION THERAPY IN THE MANAGEMENT OF CANCERS OF THE ORAL CAVITY AND OROPHARYNX. By Gilbert H. Fletcher, M.D., Radiotherapist; and William S. MacComb, M.D., Surgeon, Chief of Head and Neck Service, The University of Texas M.D. Anderson Hospital and Tumor Institute, Houston, Texas. Cloth. Price, \$16.50. Pp. 396, with numerous illustrations. Charles C Thomas, Publisher, 301-327 East Lawrence Avenue, Springfield, Ill., 1962.

THE MONTEGGIA LESION. By José Luis Bado, M.D., Professor of Surgery, University of Montevideo Medical School; Director, Institute for Orthopedics and Traumatology, Montevideo, Uruguay. Translated from Spanish by Ignacio V. Ponseti, M.D., Professor of Orthopedic Surgery, State University of Iowa Medical School, Iowa City, Iowa City, Iowa. Cloth. Price, \$6.75. Pp. 78, with 59 illustrations. Charles C Thomas, Publisher, 301-327 East Lawrence Avenue, Springfield, Ill., 1962.

ROENTGENOGRAPHIC CEPHALOMETRICS. Proceedings of the Second Research Workshop Conducted by the Special Committee of the American Association of Orthodontists. Edited by J. A. Salzmann, D.D.S., Chairman, Special Committee on Roentgenographic Cephalometrics of the American Association of Orthodontists. Cloth. Price, \$4.75. Pp. 195, with 53 illustrations. J. B. Lippincott Company, East Washington Square, Philadelphia 5, Penna., 1961.

AN ATLAS OF POSITIVE CONTRAST MYELOGRAPHY. By James Bull, M.A., M.D., F.R.C.P., F.F.R., Radiologist, National Hospital for Nervous Diseases, and St. George's Hospital, London; and Wylie McKissock, O.B.E., M.S., F.R.C.S., Neurological Surgeon, National Hospital for Nervous Diseases, and St. George's Hospital and Hospital for Sick Children, London, England. Cloth. Price, \$9.50. Pp. 147, with 74 illustrations. Grune & Stratton, Inc., 381 Park Avenue South, New York 16, N. Y., 1962.

PROCEEDINGS OF THE CONFERENCE ON HUMAN CHROMOSOMAL ABNORMALITIES. Edited by Professor William M. Davidson, M.D., Department of Haematology, King's College Hospital Medical School, London, England; and D. Robertson Smith, M.A., M.D., Department of Pathology, Royal Berkshire Hospital, Reading, Berkshire, England. Cloth. Price, \$5.50. Pp. 148, with numerous illustrations. Charles C Thomas, Publisher, 301-327 East Lawrence Avenue, Springfield, Ill., 1962.

RADIOGRAPHIC ATLAS OF SKELETAL DEVELOPMENT OF THE FOOT AND ANKLE; a Standard of Reference. By Normand L. Hoerr, Ph.D., M.D.; S. Idell Pyle, Ph.D.; and Carl C. Francis, M.D., The Department of Anatomy, Western Reserve University, School of Medicine, Cleveland, Ohio. Cloth. Price, \$9.50. Pp. 164, with many illustrations. Charles C Thomas, Publisher, 301-327 East Lawrence Avenue, Springfield, Ill., 1962.

HUMAN AND EXPERIMENTAL BREAST CANCER. By Georgiana M. Bonser, M.D., F.R.C.P., Reader in Cancer Research, University of Leeds, Consultant Pathologist, St. James's Hospital, Leeds; John A. Dossett, M.D.; Consultant Pathologist, St. James's Hospital, Leeds; and John W. Jull, Ph.D., Lecturer in Cancer Research, University of Leeds, London, England. Cloth. Price, \$7.50. Pp. 485, with numerous illustrations. Charles C Thomas, Publisher, 301-327 East Lawrence Avenue, Springfield, Ill., 1961.

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- ROENTGENTHÉRAPIE ET ÉLECTROTHÉRAPIE DES AFFECTIONS DE LA PEAU. By F. Lepennetier, Médecin Electro-radiologiste honoraire des Hôpitaux de Paris, Ancien chef du Service Central d'Electro-radiologie de l'Hôpital Saint-Louis; and H. Rabeau, Ancien chef de Laboratoire à l'Hôpital Saint-Louis, Dermatologiste de l'Hôpital Américain de Paris, France. Cloth. Pp. 523, with 109 illustrations. Masson et Cie, Éditeurs, 120 Boulevard Saint-Germain, Paris 6^e, France, 1961.
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- LA CHIRURGIE DES MÉTASTASES GANGLIONNAIRES CERVICALES. By J. M. Spitalier and J. Colonna d'Istria. Paper. Pp. 141, with 37 illustrations. Masson et Cie, Éditeurs, 120 Boulevard Saint-Germain, Paris 6^e, France, 1961.
- L'ARTROGRAFIA DEL GINGOCCHIO. By Manfredi Del Buono and Alois Rüttimann. Paper. Pp. 135, with 135 illustrations. "Il Pensiero Scientifico" Editore, Rome, Italy, 1959.



ABSTRACTS OF RADIOLOGICAL LITERATURE

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ROENTGEN DIAGNOSIS

HEAD

BOTTERELL, E. H., LOUGHEED, W. M., MORLEY, T. P., TASKER, R. R., and PAUL, W. Use of radioactive arsenic (As^{74}) in the diagnosis of supratentorial brain tumours. *Canad. M. A. J.*, Dec., 1961, 85, 1321-1328. (From: The Departments of Surgery and Pathological Chemistry, University of Toronto, and the Neurosurgical Division, Toronto General Hospital, Canada.)

In this study of supratentorial brain tumors an intravenous dose of 1 to 1.5 millicuries of As^{74} as sodium versinate is given 20 minutes before scanning. Two scintillation counters are employed and symmetrically opposed along either side of the calvarium. A modification of the Brownell apparatus permits initial scanning for a concentrated source of positron emission followed by recordings of gamma radiation. The emitted positrons are recorded by the coincidence technique. Two separate scalars of 160:1 are used to feed a subtracting circuit which yields a differential record indicating a preponderance of either right or left gamma activity. These two paper tracings are called the "positrocephalogram" (PCG) and the "asymmetrogram" (AGG). A PCG and AGG were recorded in each patient. Usually in the positive scans the PCG and the AGG were each undoubtedly positive. Occasionally in midline lesions only the PCG detected the concentration of arsenic. In laterally situated lesions the AGG sometimes clearly indicated the tumor site when the PCG was less convincing.

Of 350 patients scanned, only 203 were examined under technically standardized conditions. In 61 of these no definite diagnosis was achieved. The remaining cases are reported. Fifty-six patients had non-neoplastic disease; resulting in only 2 positive scans. Fifty-two per cent of the 86 patients with tumor had a positive scan, including 24 of 26 meningiomas and 10 of 37 gliomas. Generally, detection of gliomas decreased with increasing histologic malignancy.

The fate of injected radioarsenic and the reason for its concentration in tumors is not well documented. Assays of As^{74} recovered in brain tumors show highest values in meningiomas, followed, in order, by glioblastomas, metastatic carcinomas and astrocytomas.

A positive scan in this series always indicated some abnormality. When tumor is suspected clinically, the confirmation provided by the scan may be judged sufficient to justify direct surgical approach. In a patient with a doubtful diagnosis who manifests no alarming symptoms, the scan may be repeated many times, without much inconvenience, as the patient is observed. Meningiomas are most easily detected and therefore this method has an important place in the

detection of recurrence in this type of tumor in that comparative outpatient studies can be made. It should be stressed that no inference as to the pathologic nature of the lesion can be made from a positive scan. A negative scan does not exclude a tumor. —James J. Snider, M.D.

ROUSSEL, J., FEUILLET, C., SCHOUMACHER, P., POIRÉ, R., and BERTHOL, Y. (Nancy, France.) Modifications pneumo-encéphalographiques après lobotomie préfrontale (confrontations radiologiques à propos de 35 observations). (Pneumoencephalographic changes after prefrontal lobotomy [radiologic comparisons in 35 cases].) *J. de radiol., d'électrol. et de méd. nucléaire*, Oct., 1961, 42, 518-529.

Prefrontal lobotomy does not produce a final status, but is the beginning of a complex development that will continue for years, perhaps indefinitely. To study this evolution the authors performed pneumoencephalography in 35 patients who had had bilateral surgery, compared the findings of 10 cases in their second postoperative years with those which had been operated on from 3 to 13 years before, and discovered prognostic signs.

Usually patients will show some dilatation of the third ventricle and anterior horns by the second year; it is of favorable prognostic import if relative stability is achieved at this point, and unfavorable if the ventricles continue to expand or if there is other evidence of atrophy outside the frontal lobes. Continued histologic activity along the sectioned cerebral areas, however, may be favorable if it tends to complete an insufficient lobotomy.

In 5 cases cysts communicating with the ventricular system were demonstrated along the track made by the leukotome. These do not indicate operative puncture of the ventricle, but are of secondary development and are not necessarily unfavorable. —Frank A. Riebel, M.D.

NECK AND CHEST

MEDINA, J., SEAMAN, W. B., CARBAJAL, P., and BAKER, DANIEL C. Value of laryngography in vocal cord tumors. *Radiology*, Oct., 1961, 77, 531-542. (Address: William B. Seaman, 622 W. 168th Street, New York 32, N. Y.)

A method of examining the larynx utilizing local anesthesia and a mucosal coating of dionosil oily is described. The technique used by the authors is essentially the same as that originally described by Powers, McGee and Seaman. Anesthesia of the laryngopharynx and upper trachea is obtained by xylocaine, in 2 to 4 per cent concentration, used as a topical spray and instilled directly into the trachea

through a curved metal cannula. Approximately 5 to 15 cc. dionosil oily is injected into the larynx and hypopharynx, through a curved metal cannula. Multiple spot laryngograms are obtained in the frontal and lateral positions during quiet respiration, phonation and the Valsalva maneuver. The technique is reliable and valuable in determining the precise extent of laryngeal neoplasms and is particularly important in the demonstration of subglottic extension.

Experience with 100 laryngographic studies by this method is reviewed. Benign polyps of the cords were studied in 8 patients prior to direct laryngoscopy and biopsy. All were clearly demonstrated. Nineteen patients with malignant neoplasms of the vocal cords were examined. Definite evidence of subglottic extension was demonstrated by laryngography in 8 patients and was strongly suspected in another patient.

Some of the normal physiologic and anatomic variations, as they appear on laryngograms, are discussed. Twenty-five roentgenographic reproductions showing the normal larynx and different types of tumor are included.—*A. W. Sommer, M.D.*

GRIMES, ORVILLE F., and FARBER, SEYMOUR M. Air cysts of the lung. *Surg., Gynec. & Obst.*, Dec., 1961, 113, 720-728. (From: The Departments of Surgery and Medicine, University of California Medical Center, San Francisco, Calif.)

Air containing cysts in the lung have been variously described as blebs, bullae, pneumatoceles, tension cysts and congenital cysts. It is believed that the all-inclusive term "air cysts" of the lung should be utilized to eliminate the confusion in terminology. The mode of development of the spaces and their location are not of great clinical significance.

Etiologically, there are four types of cysts: (1) congenital, observed in newborn infants. If multiple cysts are present in one or more segments of the lung they are probably congenital; (2) bronchial ectasia with cystic enlargement. These are usually small with a firm fibrous wall; (3) escape of air from an alveolus or respiratory bronchiole toward the periphery of the lung; (4) when this escaped air ruptures into adjacent alveoli instead of the subpleural space, larger cysts result. In the apex they are called bullae and when they produce a cluster or coalesce, the condition is termed bullous emphysema.

Air cysts are functionless. Compression of bronchi surrounding the cyst interferes with normal drainage predisposing the area to recurrent and chronic pneumonic infection. This pneumonia may obscure the cyst until clearing of the infection at which time the possibility of secondary lung abscess might be considered. The fact that the clinical course is more severe and of longer duration in lung abscess aids in the differential diagnosis.

There is some merit in differentiating thick walled from thin walled cysts. Those with thick walls are more likely to be associated with infection and hemoptysis. The thin walled cyst is more likely to rupture and be associated with disturbances in pulmonary function. This latter is due to the increase in dead space when the bronchi leading to it are patent or may be due to the compression effects on the adjacent lung. As long as the bronchi leading to it are patent there is no danger of tension developing in the cyst.

Surgical treatment was reserved for patients who had symptoms related to the cysts. The thick walled cyst is more easily excised than the thin walled cyst which may require lobectomy, unroofing with suture of bronchial openings and obliteration of the pleural space. Clinical response was excellent following surgery for both types.—*David Morse, M.D.*

LYONS, HAROLD A., VINIJAHAUKUL, K., and HENNIGAR, GORDON R. Pneumocystis Carinii pneumonia unassociated with other disease; clinical and pathological studies. *A.M.A. Arch. Int. Med.*, Dec., 1961, 108, 929-936. (Address: State University of New York, Downstate Medical Center, 450 Clarkson Ave., Brooklyn 3, N. Y.)

Pneumocystis Carinii is an organism whose taxonomic classification remains controversial but it is apparently either a protozoon or a fungus. The organism produces a pneumonia characterized by alveoli filled with eosinophilic foam-like material. The condition is rare in the United States and has been found most frequently in prematurity and early infancy. A few cases have been found in adults who had another grave illness but the current report is the first case in an adult which was unassociated with other disease.

The patient was a 4½ year old male Negro who gave a history of productive cough and increasing dyspnea for 2 months. Physical and laboratory examinations were not unusual except for fever and a leukocytosis of 34,500. A chest roentgenogram showed a diffuse density extending outward from both hilar regions and involving most of the lungs except the bases. The appearance resembled pulmonary edema. There was considerable progression of the densities 11 days later. Dyspnea became progressively worse and the patient died on the twentieth hospital day. At autopsy the lungs were bulging and firm. Histologically the alveolar septa were engorged with plasma cells and lymphocytes. The alveolar sacs contained a characteristic foamy exudate in which the small organisms could be demonstrated by Giemsa techniques.

The appearance of the roentgenogram in this disease is not characteristic. The failure to establish an etiologic agent for the illness and the roentgenographic appearance of the lungs suggested an un-

usual cause such as Hamman-Rich syndrome or alveolar proteinosis.

The authors believe that pneumocystis Carinii infections may prove to be one cause of both the Hamman-Rich syndrome and interstitial plasma-cell pneumonia. Although pneumocystis infections may simulate alveolar proteinosis there is no evidence to suggest that the two diseases are related.—*J. L. Williams, M.D.*

DANEMANN, HERSEL A., COHEN, DONALD B., and SNIDER, GORDON L. Syphilitic gumma of the lung. *A.M.A. Arch. Int. Med.*, Dec., 1961, 108, 897-902. (Address: Gordon L. Snider, Director, Division of Thoracic Medicine, Mount Sinai Hospital, California and 15th St., Chicago 8, Ill.)

This is a case report of a 70 year old white man who entered the hospital because of prostatism. A survey chest roentgenogram revealed a large homogeneous density occupying almost the entire left upper lobe. The blood serology was positive but the spinal fluid studies were normal. Cytologic examinations of the sputum were negative. Bronchoscopy revealed distortion and fixation of the left main bronchus. A left scalene lymph node biopsy was negative. A thoracotomy was performed but no resection was attempted because the surgeon felt that the hard mass was an inoperable neoplasm with mediastinal involvement. The histologic appearance of the biopsy specimen was compatible with a gumma. The mass decreased in size after 14 days of penicillin therapy. There was further marked improvement during the next 5 months and subsequent chest roentgenograms showed contraction of the left upper lobe with dense fibrous residual shadows.

The roentgenographic appearance of tertiary syphilitic lesions in the lung is not distinctive. Many types of lesions have been reported, including multiple circumscribed nodules, patchy densities and homogeneous densities involving an entire lobe or whole lung.

The importance of a histologic diagnosis in cases of pulmonary lesions of uncertain etiology is stressed.—*J. L. Williams, M.D.*

INKLEY, SCOTT R., and ABBOTT, GEORGE R. Unilateral pulmonary arteriosclerosis; unusual fibrous connective tissue growth associated; review of literature and discussion of possible physiological mechanisms involved in these changes. *A.M.A. Arch. Int. Med.*, Dec., 1961, 108, 903-915. (Address: Scott R. Inkley, University Hospitals of Cleveland, University Circle, Cleveland 6, Ohio.)

This is a case report of extensive fibrous connective tissue growths involving the great veins, posterior

mediastinum, parietal pleura, retroperitoneal tissue, pericardium and mesentery. The fibroblastic reaction was similar to that seen in retroperitoneal or periureteral fibrosis. Clinically this male patient was relatively asymptomatic except for a 17 year history of recurrent hemoptyses and occasional episodes of dyspnea. The first bout of hemoptysis occurred at age 30. At age 39, prominent blood vessels were seen along the bronchial wall at bronchoscopy. A roentgenogram showed a pleural reaction at the left lung base. At age 44, the patient was found to have a widened mediastinum, esophageal varices and hepatosplenomegaly. The left pleural reaction had not changed during the 5 year interval. Fifteen months later a splenoportogram showed no evidence of a portal vein. A portocaval anastomosis was planned but was not done when an irregular, hard, retroperitoneal mass was found in the region of the left kidney. There were also multiple hard white nodules in the liver. Postoperatively the patient developed gangrene of the ileum. This could not be resected because of a hard nodular mass in the base of the mesentery.

Postmortem examination revealed large irregular firm masses in the posterior mediastinum and retroperitoneal space, and nodules in the liver, kidneys, and mesentery. The tissue was almost bone-like in consistency and histologically showed hyalinized collagen fibers and mature fibroblasts without evidence of malignancy. The mediastinal mass involved portions of the esophagus and pulmonary arteries, and completely encased the bifurcation of the trachea. It invaded the left atrium and both pulmonary veins, and had obliterated the main left pulmonary veins and the azygos vein. The retroperitoneal mass extended upward into the hilus of the liver, laterally to the hili of the spleen and kidneys, and downward within the mesentery of the small intestine. Histologically there was marked pulmonary arteriosclerosis on the left side. Neither the cause nor the precise nature of the extensive fibroblastic process was established with certainty. There was no evidence of either cancer or infection.

There is an extensive review of the literature including a discussion of the similarity of this case to chronic thrombosis of the portal vein, chronic mediastinitis, and retroperitoneal or periureteral fibrosis. Since the lesions resemble scars histologically, the authors speculate that a constitutional abnormality analogous to that seen in keloid formers may have altered the response of this patient to some familiar biologic or chemical agent.

The unilateral pulmonary arteriosclerosis is of particular interest because in previous cases unilateral pulmonary vein obstruction has led to bilateral sclerosis of the arteries. The significance of this finding is discussed in detail and should be read in its entirety by those with a particular interest in the genesis of pulmonary arteriosclerosis.

This is an interesting case report because of the unusually extensive involvement by the fibroblastic

process. Although reports of this disease have become increasingly numerous during the last few years, the cause has not been established.—*J. L. Williams, M.D.*

BUCKINGHAM, WILLIAM B., CUGELL, DAVID W., SUTTON, GEORGE C., and MESZAROS, WILLIAM T. Causes for poor angiographic visualization of one pulmonary artery. *Quart. Bull. Northwestern Univ. M. School.*, Winter, 1961, 35, 294-299. (From: The Departments of Medicine and Radiology, Northwestern University Medical School, Chicago, Ill.)

In a series of approximately 200 pulmonary arteriograms there were 9 cases with complete or almost complete absence of filling of one pulmonary artery. In 5 cases the block was caused by tumors. These are distinguished by distortion, displacement, or abrupt change in the caliber of the pulmonary artery. In 3 cases the changes were due to inflammatory destruction of one lung. Of these 1 was due to tuberculosis and 2 to advanced bronchiectasis. These showed destruction of the lung parenchyma on the involved side and elongation and dilatation of the pulmonary artery and vein on the unaffected side. Occasionally, the artery to the involved side may be visualized. There was 1 with lack of visualization due to congenital hypoplasia of the pulmonary artery. These cases are usually associated with other congenital anomalies.—*George L. Sackett, Jr., M.D.*

MCGINNIS, KENNETH D., EYLER, WILLIAM R., and ALVAREZ, HERNAN, JR. Cardiac laminagraphy. *Radiology*, Oct., 1961, 77, 553-563. (Address: William R. Eyler, Henry Ford Hospital, Detroit 2, Mich.)

Laminagraphy of the heart has proved to be a practical, simple, and useful roentgenographic technique of continuing value in daily clinical practice. While an experienced, well adapted fluoroscopist can usually find almost all of the calcifications discovered by laminagraphy, this procedure confirms the fluoroscopic findings especially when the density is minimal. It also increases the ability to discriminate between the valves and other structures; facilitates the identification of multiple calcifications; and provides a permanent record of the amount and location of the calcifications which can be used for teaching purposes.

The laminagrams are obtained with the patient in a left lateral decubitus position as this position is easy to duplicate. The valve positions in this projection have been found to maintain a relatively constant relationship to the sagittal plane in most cases. Four laminagraphic sections at 1.0 cm. separation, beginning at the sagittal plane and extending to the left are made when the valve area is to be evaluated. Other sections are made when necessary. A diagonal line drawn on these films is described which helps to

differentiate between mitral and aortic valve calcifications in most of the cases.

Many laminagrams are reproduced showing calcifications in the mitral, aortic and pulmonary valves, the pericardium, and coronary arteries. Other uncommon sites of calcification are also illustrated: intraluminal, in a thrombus in an atrial appendage; ventricular myocardial, in an old myocardial infarction with subsequent aneurysm; pulmonary arterial, in the left pulmonary artery; and a calcified ring immediately above the area of aortic valves but not connected with the valves.—*Donald N. Dysart, M.D.*

CARLEN, SIDNEY A. The post-myocardial infarction syndrome; report of two cases demonstrating a recurrent tendency. *Canad. M. A. J.*, Sept. 9, 1961, 85, 644-648. (From: Section of Cardiovascular Disease, Department of Medicine, New Mount Sinai Hospital, Toronto, Canada.)

Transient pericarditis after a myocardial infarction is a common phenomenon occurring in about 20 per cent of patients. It is usually observed between the second and sixth days. Pericardial effusion is uncommon.

The condition known as myocardial infarction syndrome is a peculiar type of pericarditis appearing between the second and eleventh week after coronary occlusion. Pleural pain at onset is followed in a day or two by fever, persistent loud pericardial and/or pleural friction sounds, and signs of patchy pneumonitis. Roentgenographic study may reveal pericardial effusion, single or bilateral pleural effusion, and basal pneumonia. Effusions are usually serosanguineous, negative on a bacterial culture. Recovery from the immediate attack is good. Multiple recurrences may appear over several months. Corticosteroids produce dramatic and diagnostic response.

This condition closely resembles active inflammatory serositis and pneumonitis and follows 20 per cent to 30 per cent of operative procedures involving pericardiotomy and also may follow accidental trauma to the pericardium. Failure to diagnose it may result in a program of treatment hazardous to the physical and psychologic welfare of the patient.

A case is reported of a white male who developed an extensive anterior wall myocardial infarction with typical findings, which gradually disappeared by the tenth day. On the thirty-second hospital day, the patient developed sharp anginal pain and roentgenography revealed consolidation in the left lower lobe with overlying pleural effusion. A diagnosis of post-myocardial infarction syndrome was made and the patient was treated with prednisone with recovery within 24 hours. The condition recurred during the twelfth and eighteenth weeks with rapid response to prednisone in each case.

A second patient with an extensive posterolateral

myocardial infarction developed a post-myocardial infarction syndrome 10 weeks after the attack. The syndrome was unrecognized and untreated and eventually cleared spontaneously in 4 weeks. Two later episodes were recognized and responded well to prednisone therapy. The post-myocardial infarction syndrome follows about 3 per cent of myocardial infarctions with the incidence directly related to the severity of the infarction. The increased cardiac shadow caused by pericardial effusion may be misinterpreted as cardiac dilatation or ventricular aneurysm. Pulmonary consolidation and pleural rubs may suggest pulmonary infarction, bronchopneumonia, or congestive failure. Recurrences may be diagnosed as new coronary thromboses resulting in physical and psychologic crippling.

The syndrome may be distinguished from extension of myocardial infarction by the pleuropericardial type of pain, absence of characteristic electrocardiographic changes, and normal SGOT. Pulmonary infarction may be ruled out by the concomitant pericarditis, and pulmonary infection by the lack of bacterial invaders. Response to prednisone is effective both therapeutically and diagnostically.—*Leslie K. Sycamore, M.D.*

ABDOMEN

EDWARDS, D. A. W. (London, England.) Physiological concepts of the pylorus. *Proc. Roy. Soc. Med.*, Nov., 1961, 54, 930-933.

This article concerns the physiologic behavior of the segment of muscle between the body of the stomach and the duodenum. It includes the pyloric antrum which has no precise proximal anatomic limit and the pyloric ring or valve. Unlike the cricopharyngeal and cardiac sphincters, the pyloric sphincter is not a muscle band that closes an opening and keeps it closed, occasionally relaxing to let something through. Manometric examinations show that the cricopharyngeal and cardiac sphincters are formed by a segment of the wall of the gut tube which has a separate innervation. The muscle is tonically contracted and this contraction only relaxes for a short period of time to allow a bolus to be pushed through. Similar examinations of the pyloric sphincter show no evidence of a segment with a sustained rise of squeeze pressure. It does not significantly resist being distended to a bore of at least 7 mm. most of the time. Usually there is little or no resistance to the pyloric sphincter being stretched to 7 to 12 mm. in diameter or even occasionally up to 20 mm. in diameter. About three times a minute the pylorus closes firmly and about every 60 to 90 seconds a giant contraction occurs involving the pyloric antrum, pyloric segment and the proximal part of the duodenal cap. The author concludes that the pylorus acts statically as a filter by virtue of the relative narrowness of its bore, holding back lumps of food but capable of varying its bore from nothing to

20 mm. or more. It also acts dynamically as a pumping machine which provides one of the important motive powers for emptying the stomach.

Several forces might explain the propulsion of the barium from the stomach into the duodenum. The force of gravity is often very small but if the resistance to flow into the duodenum is negligible, it may be adequate to cause the flow of barium. Gastric peristalsis probably merely mixes the contents of the stomach and does not propel them. The pyloric antrum contracts about three times a minute and every fourth, fifth or sixth wave is accompanied by a simultaneous contraction of the proximal part of the duodenal cap and pyloric ring forming the so-called pyloric pump. These waves seem to form the main propulsive activity of the stomach although they are not essential to emptying since the stomach empties at about the same rate after a pylorotomy. The duodenum and small bowel act as a conveyor belt and promptly carry away barium or food which reaches them from the stomach. Little or no gradient of pressure is required to feed this conveyor belt. Resistance to flow may be produced by resistance to stretch of the pyloric segment or pyloric ring, or by the duodenal cap or beyond.—*Arthur E. Childe, M.D.*

EDWARDS, DAVID. (London, England.) Some radiological aspects of pyloric disease. *Proc. Roy. Soc. Med.*, Nov., 1961, 54, 933-937.

The pyloric antrum is that portion of the stomach which lies distal to the incisura. Distally it narrows to form the pyloric ring. The author states that the mean length of this ring is 6 to 7 mm. and that any ring which exceeds 12 mm. in length should be carefully examined with grave suspicion.

Mucosal relief roentgenograms of the pyloric region are essential. Double contrast roentgenograms of the pylorus should be obtained but often at this stage the antrum is distended and early changes in the mucosa may be obliterated completely.

The author has reviewed reports on 67 consecutive proven cases of carcinoma of the pylorus by all members of the department, from the most junior to the most senior. There was an accuracy of 86.6 per cent. He feels that in the absence of pyloric obstruction there should be little difficulty in recognizing the true nature of a malignant ulcer. Gastric sarcoma is rare. Secondary involvement of the stomach from adjacent lymph nodes is not uncommon in the lymphomata. The stomach is rarely the site of the primary tumor in this condition. The appearance may be indistinguishable from carcinoma but extensive involvement of the duodenum may suggest the correct diagnosis.

Benign tumors of the stomach are surprisingly common. The great majority are very small and do not produce symptoms. Malignant changes occur particularly in the adenomatous polyp, the leiomyoma and the neurogenic tumor.

The idiopathic form of hypertrophic pyloric

stenosis is rare in adults. Sometimes it is due to persistence of the infantile form of the disease treated medically. The secondary form is associated with some other lesion such as peptic ulceration of the stomach or duodenum or tumor of the stomach.—*Arthur E. Childe, M.D.*

JOHNSON, H. DAINTREE. (London, England.) The pylorus: its function and some surgical considerations. *Proc. Roy. Soc. Med.*, Nov., 1961, 54, 938-940.

Manometric studies have shown that, except during hunger spasms, intragastric pressure remains fairly constant and is unaffected by peristaltic activity. There is simply a constant steady squeeze due to muscle tone. The duodenal cap behaves quite differently from the stomach and resembles a little muscular bag undergoing rhythmic systole and diastole. The author believes that the function of the pylorus is to prevent reflux into the stomach during systole of the duodenal cap. He feels that the whole mechanism of gastric emptying closely resembles, on a less vigorous scale, the mechanism of the heart; the atrium taking the place of the stomach, the ventricle that of the duodenal cap, and the mitral valve representing the pylorus. Like the heart, the gastroduodenal pump drives fluid from a region of low pressure to one of high pressure. The pylorus is not necessary to prevent material from leaving the stomach too quickly and it is not essential for the working of the gastroduodenal pump. However, the pump is less efficient without it and much more reflux of bile into the stomach occurs. Scarring from a duodenal ulcer interferes with cap systole and slows down gastric emptying by preventing normal diastolic filling.

Functional pyloric stenosis is due to edema and spasm associated with ulcer activity. Pure organic obstruction is due to scarring and often the ulcer is healed. It is a dangerous condition and should always be treated surgically as soon as recognized. The largest clinical group of patients have a combination of scarring and the edema and spasm of an active ulcer. These patients respond best to a period of medical treatment followed by surgery after a few weeks.

Retained material in the stomach tends to mop up acid and exerts an important curative effect on a duodenal ulcer. However, retention of protein in the stomach is apt to promote prolonged secretion of gastrin and hence of hydrochloric acid. This may succeed in undermining the defenses of the stomach itself with the formation of a gastric ulcer. The surgeon must realize that patients with combined duodenal and gastric ulcers are hypersecretors of acid and he must treat them radically.—*Arthur E. Childe, M.D.*

SKELETAL SYSTEM

KLEIGER, BARNARD, and MANKIN, HENRY J. A roentgenographic study of the develop-

ment of the calcaneus by means of the posterior tangential view. *J. Bone & Joint Surg.*, Oct., 1961, 43-A, 961-969. (From: The Hospital for Joint Diseases and the Leo Mayer Orthopaedic Group, New York, N. Y.)

The authors have made a careful roentgenographic study of the development of the posterior portion of the foot by using mainly a posterior tangential roentgenogram showing the os calcis and the talus. They have accomplished several things including a demonstration of the normal development of the ossification centers of the calcaneus and the talus. In the normal foot the posterior facet appears at the age of six months and the sustentaculum tali appears between one and two years of age and is fully developed at four or five years. They have been able to point out the differences between the development of the normal, the flat, and the club foot. In the flat foot the calcaneus is everted, the subtalar joint surface is inclined medially and the sustentaculum tali is lowered. In the club foot the calcaneus is inverted, the subtalar joint inclines in the reverse direction, and the sustentaculum tali is markedly elevated. The authors believe that their study has provided additional roentgenographic criteria for the diagnosis of these deformities of the foot.

The posterior tangential roentgenogram is made with the subject standing on a cassette with the feet in a parallel position. The roentgen-ray tube is 36 inches behind the target and is directed anteriorly and inferiorly at the ankle joint at an angle of 45° with the long axis of the lower extremities.

The article is profusely illustrated with reproductions of 12 roentgenograms; there is a photograph of the technical aspect of obtaining the roentgenograms; and there is one sketch with anatomic definitions.—*R. E. Kinzer, M.D.*

REILLY, WILLIAM A., and GORDAN, GILBERT S. Dissociation of growth-stimulating and skeleton-maturing actions of the synthetic androgen, fluoxymesterone. *J. Pediat.*, Aug., 1961, 59, 188-193. (From: The Endocrine Clinics of the Departments of Pediatrics and Medicine, University of California School of Medicine, San Francisco, Calif.)

The initial rapid increase in height with ultimate stunting of growth in patients with adrenocortical hyperplasia is well known. This is due to the growth accelerating factor combined with the skeletal maturation factor of the endogenous androgens. It is postulated that an agent capable of accelerating linear growth without speeding epiphyseal fusion would increase height.

Fluoxymesterone is a new synthetic androgen derivative. It was administered, usually in 5 mg. daily doses, to 16 prepuberal children because of

familial short stature, gonadal dysgenesis, delayed puberty or hypopituitarism. The heights were recorded every three months and the skeletal age was determined by a single roentgenogram of the hand and wrist every six months. In 13 children the rate of growth for the preceding year had been 1.9 inches. During treatment the rate rose to 3.2 inches per year, similar to that of a normal or methyltestosterone induced puberal growth spurt. The skeletal age advanced an average of ten months during each year of treatment. Phallic enlargement was the only androgenic effect observed. There resulted a 1.9 inch average increase in the predicted adult height. This was believed to be due to the combination of growth production and relatively slow skeletal maturation caused by exogenous fluoxymesterone.—*D. Morse, M.D.*

MARMOR, LEONARD, and BECHTOL, CHARLES O. Spondylolisthesis; complete slip following the Gill procedure: a case report. *J. Bone & Joint Surg.*, Oct., 1961, 43-A, 1068-1069. (From: The Department of Surgery, Division of Orthopedic Surgery, University of California Medical Center, Los Angeles, Calif.)

The authors state that the treatment of spondylolisthesis is a controversial subject. They believe that removal of the posterior arch weakens the involved area and they indicate that if the arch is removed spinal fusion is indicated. They report a case in which a patient was treated by the Gill procedure and did not have spinal fusion. Two years later, a lateral roentgenogram of the lumbosacral area showed complete slipping of the fifth lumbar vertebra over the anterior prominence of the sacrum. A Hibbs-type spine fusion was then carried out and the patient is reported to have done very well thereafter.—*R. E. Kinzer, M.D.*

BLOOD AND LYMPH SYSTEM

DOTTER, CHARLES T., STRAUBE, KURT R., and STRAIN, DOUGLAS C. Circulatory arrest: manual and mechanical means for emergency management. *Radiology*, Sept., 1961, 77, 426-433. (Address: University of Oregon Medical School Hospital, Portland 1, Ore.)

In the year following introduction of closed chest compression, many lives have been saved by its use, and all radiologists should be familiar with the method.

The authors report one case where circulatory failure occurred shortly after the injection of hypaque into the proximal aorta, and viability was maintained by this method and open chest cardiac massage for 2½ hours. Pressure tracings made during massage indicated that external compression was more effective than open chest methods for maintaining periph-

eral pressures. A machine was then built to apply compression to the lower chest in a similar manner to that done by hand. This was tried on a heparinized cadaver, and appeared to have merit. The machine subsequently was tried on a patient with acute ventricular fibrillation, and systolic pulses were observed in the femoral vessels, although pressure tracings were not obtained. The authors have planned a second machine with improvements suggested by the first. In addition, two more cases of circulatory failure that were undergoing left heart catheterization are reported, and are thought to have been saved by manual external chest compression.

Ventricular fibrillation is a mode of death, rather than a primary cause. When it represents a by-product of a sudden but temporary myocardial insult, such as a small infarct, transient hypoxia, electrical shock, or reaction to a contrast agent, prompt reoxygenation of the myocardium may permit defibrillation and recovery. The exact moment when irreversible cell death occurs in human myocardial infarction is not clear, and reoxygenation of the ischemic myocardium must be the basic rationale of the therapy of coronary disease. Regardless of how it is done, the successful institution of artificial circulation within two minutes of "death," due to acute myocardial infarction, may give the patient a second chance.—*J. C. Moore, M.D.*

MEYERS, HARVEY I., and JACOBSON, GEORGE. Death following intravenous carbon dioxide angiocardiology. *Radiology*, Aug., 1961, 77, 295-296. (Address: 1200 North State Street, Los Angeles 33, Calif.)

The first known death following the intravenous injection of carbon dioxide to outline the right atrial wall and adjoining structures roentgenographically is reported.

The patient, a forty-eight year old Negro female, was admitted to the hospital because of swelling of the feet and legs, and shortness of breath. Roentgenograms of the chest demonstrated extensive infiltration of both lungs, several cavities in the right upper lobe, and a moderately enlarged heart. Angiocardiography was undertaken to determine whether or not pericardial effusion was present. Approximately three minutes after the injection of 100 cc. of CO₂ into the antecubital vein through an intravenous infusion tube with the patient in the left-lateral decubitus position, the patient became unresponsive with no audible heart beat or spontaneous respirations. Spontaneous heart beat was restored by cardiac massage, but death occurred four hours after the onset of cardiac arrest. An autopsy was not permitted.

The exact cause of death in this case is unexplained. It is unlikely that the amount of CO₂ injected, gas embolism, or diffusion of nitrogen into the CO₂ bubble could be responsible for the death.

The high degree of safety of the procedure has been pointed out by other authors.—*W. H. Jarvis, Jr., M.D.*

HAMILTON, LONGSTREET C., MC, USA, and WELDON, WILLIAM V., MC, USA. Antegrade aortography and arteriography; further experience with the method; its place in arterial opacification technics. *Radiology*, Sept., 1961, 77, 406-417. (Address: U. S. Army Tripler General Hospital, A. P. O. 438, San Francisco, Calif.)

The authors present a critical analysis and evaluation of their experience in 125 aortographic examinations by the intravenous method. Of particular interest is their attention to the questions of safety, indication, and preference as compared to retrograde aortography and arteriography.

The described technique consists of mechanical injection of a bolus of medium through a catheter with the tip positioned in the right atrium. Various circulation times were utilized, including radioisotopic methods, and filming was accomplished with the Schönadner apparatus with multiple exposures, up to 20 seconds after injection. The interested reader is referred to discussion and tabular data on circulation time, opacification time, dose of medium, injection rate, value of auxiliary films and complications, of which none were major.

The authors conclude that antegrade aortography is a safe and easily performed procedure with a wide range of indications, especially in arteriosclerotic disease of the aorta and its major branches. Although it is a suitable survey procedure for problems of vascular insufficiency in the head and neck, direct and selective intra-arterial injection is to be preferred in problems clinically localized to the head and neck or renal arterial system.—*Edward B. Best, M.D.*

SCHOBINGER, ROBERT A., KRUEGER, ERICH G., and SOBEL, GARRISON L. Comparison of intraosseous vertebral venography and pantopaque myelography in the diagnosis of surgical conditions of the lumbar spine and nerve roots. *Radiology*, Sept., 1961, 77, 376-397. (Address: VA Hospital, Bronx 68, N. Y.)

A comparative study of intraosseous epidural venography and myelography in 68 patients with a variety of lesions of the lumbosacral spine (disk protrusion, congenital malformation, adhesive arachnoiditis, radiation myelitis, and/or radiculopathy, primary and metastatic tumors) is presented. Venography was performed in all and myelography in 51 patients, with surgical confirmation of the diagnosis in 48 instances.

The patient is placed in the prone position on an inflatable balloon on top of a wedge shaped film

tunnel which was designed to hold a 10×12 inch film in a stationary grid cassette. Under local anesthesia, a 16 gauge bone marrow needle is introduced into the medullary cavity of the spinous process by rotary motion of the hand. One vertebra caudad to the level of suspected abnormality is preferred as the site of injection. It is emphasized that peripheral bone marrow containing bone marrow particles must be freely aspirated prior to the injection of any substance. Strict adherence to this rule will prevent inadequate injection. After correct placement of the needle, 2 to 3 cc. of procaine is injected directly into the marrow cavity. One or 2 minutes thereafter, an average of 25 cc. of 50 per cent hypaque is rapidly introduced within 5 seconds or less, after tightening of a constriction band and adequate inflation of a compression balloon. One film exposed during the injection of the last 2 or 3 cc. of contrast medium is immediately developed and furnishes the desired information. Venograms obtained in the posteroanterior projection seem to furnish the most information but it is customary to add a venogram in the straight lateral projection, while the patient executes a Valsalva maneuver.

In normal venography, the contrast medium promptly escapes the medullary cavity of the injected bone into the external and internal vertebral venous plexuses. The radiopaque material usually outlines these plexuses in cephalad and caudad direction only over a few vertebral spaces. This is best observed in the lateral view without compression of the inferior vena cava. If, however, the inferior vena cava is temporarily occluded a definite cephalad direction of flow within the internal vertebral venous plexus does occur. Normally, the system of epidural veins appears in the posteroanterior projection as a continuous ladder of venous structures. Deviation from this continuous pattern indicates an obstruction affecting the flow within the vertebral venous plexus cephalad to the level of injection.

Venography was found to be a sensitive indicator of displacements or obstructions of the epidural veins due to lumbar disk protrusion. Angiograms obtained in the posteroanterior projection, with temporary occlusion of the inferior vena cava, were found to be most suitable for demonstration of the abnormality. Compression or deviation of the epidural veins was found to produce evidence of increased collateral circulation of the external vertebral venous plexus and ascending lumbar veins. There was also evidence of flow of contrast medium in a distal direction to a degree not observed under normal conditions. In mild disk protrusion, only a lateral deviation or mere thinning of the epidural veins corresponding to the level of the lesion was observed on frontal views, and a posterior displacement was seen on the lateral projection. Pronounced herniations were found to produce complete interruption of the epidural veins. As was to be expected, spondylolisthesis produced marked alteration of the venographic picture, in

some cases amounting to complete epidural venous obstruction.

Two patients with intradural tumors were examined by venography. One patient with an ependymoma of the cauda equina showed a pattern of the occlusive type. The venogram gave the impression that contrast medium had been squeezed from the epidural veins, the latter being compressed by the intradural mass. Another patient with an intramedullary glioma extending from the lower cervical to the upper dorsal spine revealed a complete block of the epidural veins with shunting of the radiopaque substance over dilated veins of the external vertebral plexus.

In the presence of malignant lesions involving the spine, there was complete interruption of the flow of contrast medium at the level of the neoplastic process. Frequently, the intervertebral, lumbar, and ascending lumbar veins appeared obstructed in the vicinity of the neoplasm. With the inferior vena cava compression or Valsalva exercise, contrast substance was usually absent in the epidural veins cephalad to the lesion.—*A. W. Sommer, M.D.*

MOULONGUET-DOLERIS, P., ARVAY, N., PICARD, J. D., and MANLOT, G. (Paris, France). La lymphographie: technique, indications et résultats (conclusions portant sur 230 explorations). (Lymphography: technique, indications and results [experience based on 230 cases].) *J. de radiol., d'électrol. et de méd. nucléaire*, June-July, 1961, 42, 281-296.

After a historic review of lymphography the authors describe the technique which they used on 230 cases.

Two cubic centimeters of a 10 per cent solution of Blue Violet dissolved in 2 per cent xylocaine are injected at the level of the great toe of the foot that is being investigated.

The lymphatics in the area pick up the dye and assume a blue color. A cut down on the dorsal aspect of the foot is made and the lymphatic vessel is catheterized. This requires a very fine needle with a sharp bevel. The contrast material used is radioselectan 76 per cent which is the same as that used for urinary or cardiovascular studies. This is warmed to body temperature and 6-12 cc. are injected. The proper rate of injection can be gauged—too slow an injection of the contrast material will result in unsatisfactory opacification, while rapid injection may result in rupture of the lymphatic vessel well above the site of injection.

The progression of the contrast material through the lymphatics of the lower extremities is assessed by the progression of pain. The latter is experienced up to Scarpa's triangle beyond which pain is no longer felt by the patient. Exposures are made on an ordinary roentgenographic table, successively including the leg, the knee, the thigh, the inguinal region

and the area of the pelvis.

If both extremities are to be examined at the same time, two operators inject simultaneously maintaining the same rate and pressure of injection. When the injection is terminated the site of the cut down is closed with two or three sutures.

The authors consider the examination to be a relatively difficult and delicate procedure which is not always successful. However, with patience and experience it should be completed within one hour.

Unpleasant results noted have been a slight to moderate edema of the foot and leg lasting one to two days following the examination, and rupture of the lymphatics with diffusion into the surrounding soft tissues. In two cases ulceration occurred between the site of injection into the great toe and the incision at the dorsal aspect of the foot. This healed within two weeks. Moderate urticaria was observed in one patient who was evidently sensitive to the contrast material used; this was well controlled following the use of antihistamines. Only in one case was there a lymphatic fistula with lymphorrhea; following suture this healed adequately.

Considerable anatomic variations occur in the course of the lymphatic vessels. However, certain constant patterns can be observed which with experience will be recognized as a standard for evaluation of the normal and the abnormal.

Pathologic findings noted by the authors in the lymphatic vessels include dilatation occurring in lymphedema. Though rare, this is usually found with metastatic involvement of the regional lymph nodes. However, it may also accompany an inflammatory process.

Alterations in the lymph nodes may be inflammatory or may be due to metastatic involvement. The inflammatory lymph nodes are large, but retain a regular outline and contour. Their opacification is homogenous, and they retain the contrast material for a long time. The metastatic lymph nodes are irregular in outline and are irregularly opacified.

The authors' cases were almost exclusively limited to the lower extremity in as much as their work involved a high percentage of patients from a gynecologic service with carcinomas of the uterus, vulva and vagina. A few cases of epitheliomas of the soft tissues are included.

Three sketches, reproductions of two photographs and fifteen roentgenograms accompany this excellent article.—*William H. Shehadi, M.D.*

RADIATION THERAPY

GUILLAUME, J., MALAISE, E. P., and LABEYE, R. Nouveau système de conditionnement des aiguilles et tubes de radium. (New system of storing radium needles and tubes.) *J. belge de radiol.*, 1961, 44, 333-341. (Address: J. Guillaume, Centre Anticancéreux, Université de Liège, Belgium.)

A storage unit for 1,850 gm. of radium was built and designed as follows: 42 steel drawers each 2×2 cm. and 1.20 m. deep were spaced in a matrix of reinforced barium concrete which was vibrated during placement. The mid-portion of each drawer was filled with lead, leaving a distal recess for radium sources, none of which exceeded 50 mg. Measurements at the front steel wall were calculated as averaging 120 μ r/hr.—*Frank A. Richel, M.D.*

LEAMONG, ROBERT H., STEARNS, MAUS W., and DEDDISH, MICHAEL R. Preoperative irradiation in rectal carcinoma. *Radiology*, Aug., 1961, 77, 257-263. (Address: Box 259, Route 3, Boonton, N. J.)

The authors review the statistics on 1,786 patients with primary adenocarcinoma of the rectum or rectosigmoid seen at Memorial Center between 1939 and 1951. Of this number, 1,276 were subjected to celiotomy, 727 with preoperative roentgen therapy and 549 without. It was found that the resectability rates of those who did not have preoperative roentgen therapy was 86 per cent and those who did 69 per cent. The probable explanation for this is that all patients seen, regardless of the state of operability, are included: the borderline operable who were irradiated before exploration and a large number who were deemed inoperable and treated by irradiation with subsequent colostomy merely to relieve obstruction.

The over-all five year survival rate in the entire series of 1,786 patients was 28.5 per cent. For those patients subjected to celiotomy, but who had no resection, the survival rate was 37.4 per cent, and if a resection was performed it was 49 per cent. Those who had a celiotomy, but no resection and no preoperative irradiation showed a survival rate of 41 per cent; with roentgen therapy it was 35 per cent. Patients in whom resection was accomplished at the time of celiotomy showed a 47.5 per cent survival rate when no irradiation had been given preoperatively, and 51 per cent when it had.

A significant finding in this study is that although preoperative irradiation did not influence the survival rate in patients without lymph node involvement, it did improve the survival in those with lymph node metastases from 23 to 37 per cent. This 14 per cent increase in the over-all survival rate is a substantial improvement in the salvage in a group currently having the poorest surgical outlook. It is felt that the optimum time for surgery after a course of irradiation is within one month. The reason for this is that liver metastases were found to be present in an increasing number of patients at the time of surgery when the time interval between roentgen therapy and surgery was increased.

The preoperative irradiation was delivered with conventional orthovoltage equipment with a half value layer of 1.5 mm. Cu and a target-skin distance

of 50 cm. or 70 cm. Two anterior, two posterior, and two lateral pelvic ports measuring 14×11 cm. were routinely used, with the addition of a perineal port if the lesion was located within 8 cm. of the anal verge. A tissue dose varying from 1,200 r to 1,600 r was usually delivered in a period of ten to twelve treatment days or an over-all time of two weeks. While the authors make no pretense that the lymphatics of those lesions with lymphatic spread were sterilized by this tissue dose, they feel that large bulky, apparently inoperable lesions were made operable by relief of an associated inflammatory process. The fact, however, that there has been this significant increase in the five year survival of these patients suggests a benefit beyond the anti-inflammatory response. The mild erythema produced by this course of irradiation in no way interfered with subsequent surgery or healing, and there were no untoward effects during the preoperative period.

An appeal is made to consider more often the use of preoperative irradiation in patients with rectal carcinoma.—*Donald N. Dysart, M.D.*

LEABHART, J. W., and BONFIGLIO, M. The treatment of irradiation fracture of the femoral neck. *J. Bone & Joint Surg.*, Oct., 1961, 43-A, 1056-1067. (From: The Department of Orthopedic Surgery, University Hospitals, State University of Iowa, Iowa City, Ia.)

Spontaneous fractures of the femoral neck, secondary to the effects of irradiation, were not reported in the American literature until 1936. The authors of the original report remarked that obliterative endarteritis might be a factor in the production of these lesions.

In 1947 and in 1952 Stampfli, Kerr, and Bonfiglio reported two additional series of patients and it was their opinion that the irradiation fractures represented stress or fatigue type fractures through a zone of osteoporosis which was produced by the irradiation. These authors did not feel that endarteritis was the cause of the fracture. They felt certain on the basis of 9 or more biopsies that the occurrence of aseptic necrosis was rare and stressed that these fractures showed a strong tendency to heal.

The present authors report on a total of 56 fractures which were treated. The average age of the patient was 58.5 years at the time of irradiation and the average dose was 3,600 r in the parametrial area. The average interval from irradiation to the onset of pain in the hip was 36.6 months and the interval from the onset of pain to diagnosis was 3 months. They point out that the presenting complaint was usually pain in the groin and medial portion of the thigh. They note that changes occur in the acetabulum as well as in the femoral neck. Definite conclusions are not drawn but the authors indicate that early internal skeletal fixation is the choice method. If reduc-

tion of deformity is necessary, bone grafts should be used. They indicate that reconstruction procedures including cup arthroplasty or insertion of a prosthesis are effective in certain cases.

It is apparent that earlier diagnosis and prompt treatment by internal skeletal fixation are the two most important considerations in obtaining good results in this type of fracture.—*R. E. Kinzer, M.D.*

RADIOISOTOPES

MALAISE, E. P., LAPIÈRE, M., LABEYE, R., and GUILLAUME, M. J. Traitement des angiomes plans chez des enfants en bas age par des plaques imbibées d'yttrium⁹⁰. (Treatment of flat angiomas in young children by plaques impregnated with yttrium⁹⁰.) *J. belge de radiol.*, 1961, 44, 277-287. (Address: E. P. Malaise, 162 Grand-route, Beyne-Liège, Belgium.)

Flat angiomas can be precisely and homogeneously treated, according to the authors, by the use of thin plastic sheets the surfaces of which bear measured quantities of yttrium 90. The sheets are enclosed in plastic envelopes, hermetically sealed to avoid contamination.

To achieve perfect contact 2 molds of the child's face are made. From one of these a positive plaster model is formed and the lesion traced thereon by projecting a colored photograph of the child. From this model a fabricator develops a perfectly fitted radioactive applicator which in turn is held in place by the second mold.—*Frank A. Riebel, M.D.*

HOLODNY, EDWARD, LECHTMAN, HEATHER, and LAUGHLIN, JOHN S. Bone-marrow dose produced by radioactive isotopes. *Radiology*, July, 1961, 77, 1-11. (Address: E. Holodny, 444 East 68th St., New York 21, N. Y.)

Experimental studies to determine the radiation dose distribution throughout the body, produced by internally located radioactive isotopes, are described. The absorbed dose produced in bone marrow by radium treatment of carcinoma of the cervix was measured in a realistic adult female phantom consisting of wax and cork and containing a real skeleton. The marrow cavities of the bone were filled with beeswax. Small holes were drilled in certain selected bones for positioning of miniature specially designed and constructed ionization chambers.

Three different arrangements of the Manchester cervix applicator were used to determine bone-marrow doses produced by standard radium insertions. The first utilized a three-tube tandem containing 37.5 mg. with a 25 mg. tube in each of two small vaginal ovoids. The second arrangement consisted of a two-tube tandem containing 25 mg. in the uterine portion, and two vaginal ovoids each containing 25 mg. of radium. In the third set of measurements only

the two vaginal ovoids, each containing 25 mg. of radium, were used without any radium in the uterine tandem.

Measurements were made with the first of the three cervix applicators to determine the doses received by Points A and B (as described by Tod and Meredith). The measured dose at Point A was 75.9 r/hr. and the dose at Point B was 25.0 r/hr. The mean absorbed active marrow dose produced by radiation from this applicator containing 87.5 mg. of radium was found to be 99.7 rads in forty hours. The mean absorbed doses to the bones which contain most of the active marrow in adults are recorded as follows: femoral head and neck—8.65 rads, lumbar vertebrae—16.9 rads, sacrum—27.3 rads, os coxae—44.8 rads. The mean absorbed dose for the smallest applicator which contained 50 mg. of radium was 58.7 rads. The integral active marrow dose ranged from 1.04×10^6 gram-rads for the largest applicator to 0.61×10^6 gram-rads for the smallest. All exposure periods were forty hours.—*Arno W. Sommer, M.D.*

MISCELLANEOUS

GIRDANY, BERTRAM R., GAITHER, EDWIN S., and DARLING, EDWARD B. Large screen image amplification with closed-circuit television employing television tape-recorder. *Radiology*, Aug., 1961, 77, 286-290. (Address: Children's Hospital of Pittsburgh, 125 DeSoto Street, Pittsburgh 13, Pa.)

As more extensive use of motion studies is made, every effort must be concentrated on limiting the amount of radiation during any given examination. New equipment utilizes television tape-recording of the fluoroscopic image, mediated through a newly developed image Orthicon television camera optically coupled to a 9-inch image amplifier. The system permits recording on television tape and simultaneous viewing on the closed-circuit television monitor at the same low levels of radiation as are required for closed-circuit television viewing alone.

Convenience of viewing and improved teaching are the major advantages of closed-circuit television observation of fluoroscopic images. The addition of television tape-recording broadens these basic advantages. The television tape can be played back immediately for re-evaluation by the radiologist or in consultation with other members of the hospital staff. The tape may be stored or it can be transferred via a cine-recording camera, to fine-grain movie film which is necessary for single frame or slow motion viewing. The recording on the tape is erased when it is used to record other examinations. All fluoroscopic examinations are readily recorded and may be viewed at leisure an unlimited number of times, without re-exposing the patient to radiation, and without requiring services of other personnel necessary in re-examinations. Resident training can be more

easily supervised and a library of fluoroscopic examinations can be available as "teaching file" films. Controversial and puzzling problems can be reviewed at times convenient for consultants. The fluoroscopic examiner observes infinitely more when he reviews a taped recording of his examination, at which time all of his resources can be concentrated on the viewing process. Immediate play-back allows the examiner to be certain of the technical quality of his examination—that he has demonstrated what he wants to visualize. The low levels of radiation needed for recording allow prolonged, or repeated, examinations without radiation hazard becoming a limiting factor. The availability of sound recording on the television tape offers a new and largely unexplored field for simultaneous studies of motion radiography with sound.—*Walter H. Jarvis, Jr., M.D.*

POTSAID, MAJIC S., and IRIE, GORO. Paraffin base halogenated hydrocarbon chemical dosimeters. *Radiology*, July, 1961, 77, 61-65. (Address: M. S. Potsaid, Massachusetts General Hospital, Boston 14, Mass.)

Halogenated hydrocarbon radiation dosimeters have been studied for years, particularly as aqueous and nonaqueous systems.

This report concerns the usefulness of bromoform and chloroform solid nonaqueous chemical dosimeters, with particular reference to three dimensional isodose pictures of absorbed dose from all forms of ionizing radiation. Several mixtures were tried, but the best seemed to be a paraffin-wax combination mixed with chloroform and bromoform in concentrations of halogenated hydrocarbon ranging from 4 to 40 per cent by weight. Each kilogram of mixture contained 100 mg. of methyl yellow aminoazobenzene. The usual halogenated hydrocarbon content was 7 to 8 per cent. The mixture was cast in block form, and produced a yellow solid which changed to red upon exposure to ionizing radiation. The color change is instantaneous and proportional in intensity to the amount of ionizing radiation. There appears to be little or no dependence on energy or dose rate in the ranges of 50 to 2,000 kvp. and 1 to 1,000 rads per minute. These dosimeters are moderately sensitive to other energy and must be protected from ultraviolet light and direct sunlight. After radiation exposure the dosimeter keeps better for long periods

when kept in a refrigerator. A small amount of water decreases the radiation response.

It is hoped that other materials may be used in the future which will be transparent, firmer, and tissue equivalent.

Other studies for application of the dosimeter are outlined.—*James C. Moore, M.D.*

MARCH, HERMAN C. Leukemia in radiologists, ten years later; with a review of the pertinent evidence for radiation leukemia. *Am. J. M. Sc.*, Aug., 1961, 242, 137-149. (Address: 7222 Castor Avenue, Philadelphia 49, Pa.)

In reports of 1944 and 1950 the author called attention to the increased incidence of leukemia in radiologists in the United States. The present report is an extension of the previous statistics to cover the decade from 1949 to 1958 inclusive. The total number of deceased radiologists, gathered from records of the national radiological societies and supplemented by a personal scrutiny of obituary notices published in the *Journal of the American Medical Association*, supplied the material for the study.

The incidence of death from leukemia in radiologists in the United States for the decade 1949 to 1958 is about four or five times as great as in non-radiological physicians. This is approximately one-half the differential that existed in the preceding two decades and it is anticipated that the differential will further diminish because radiologists are aware of the problem and are taking adequate protection.

The causal relationship of ionizing radiation with some cases of leukemia is fairly well established by experimental work, data from the atomic bombing incidence, studies in radiologists, and studies of patients treated for ankylosing spondylitis by roentgen irradiation. Suggestive supportive evidence comes from study of patients who had received irradiation of the thymus gland during infancy. Evidence from patients who were given therapeutic doses of radioactive iodine, and infants who were subjected to antenatal fetal diagnostic irradiation, is doubtful.

The majority of investigators holds that there is a linear dose-response relationship in radiation leukemogenesis, but there is good authority also for the concept of a nonlinear relationship. Whether there is linear relationship for small doses or whether there is a threshold dose remains an unsettled problem.—*Lois Cowan Collins, M.D.*



CENTRAL FRACTURE-DISLOCATION OF THE HIP TREATED BY OPEN SURGERY

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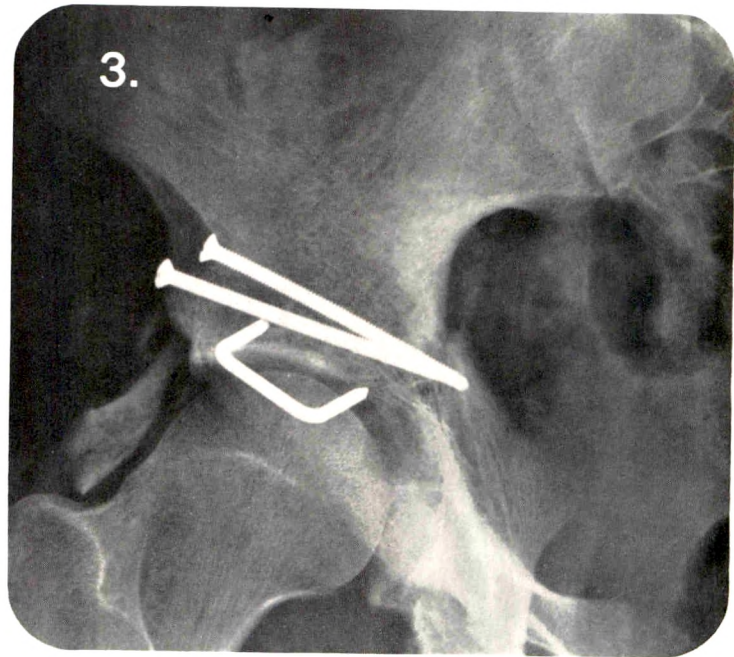
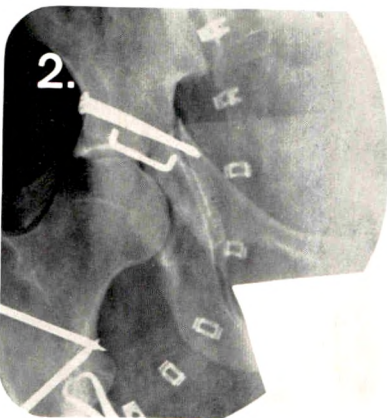
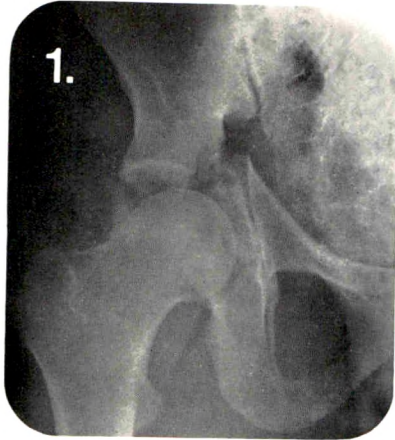


Figure 1. Prior to surgery.

Figures 2 and 3. During and after surgery.

Anatomical Orientation: Iliac crest is shown above; iliopsoas medially held by Bennett and Hibbs retractors at left. Straight head of rectus femoris not detached. Lateral retraction of tensor fascia lata and anterior portion of gluteus medius.

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Figure 4. Anterior iliofemoral incision. Left.

CENTRAL FRACTURE-DISLOCATION (*continued*)

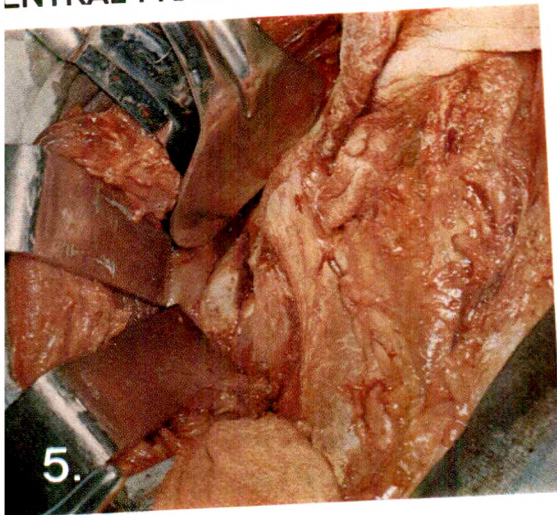


Figure 5. Fracture of acetabulum through iliopubic eminence. Femoral head barely visible through fracture line.

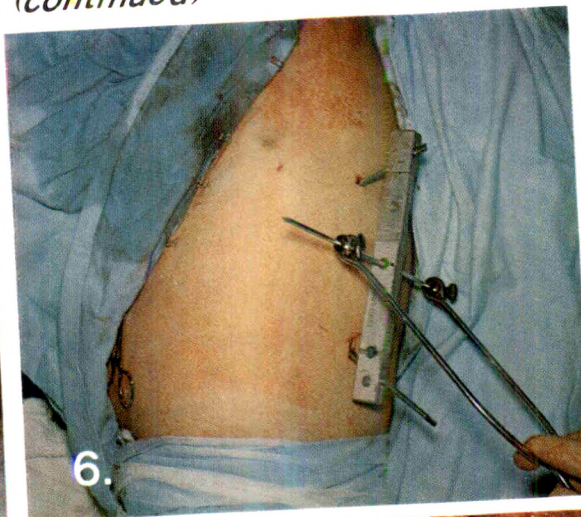


Figure 6. Insertion of Roger Anderson device for lateral traction.

Figure 7. Insertion of heavy threaded pins on either side of fracture line to facilitate reduction.

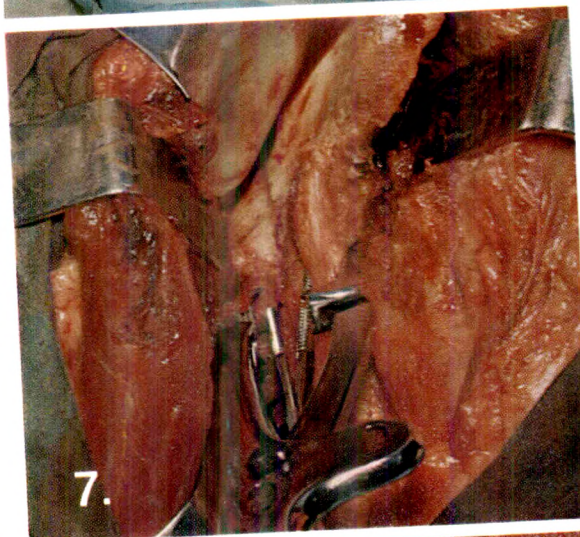
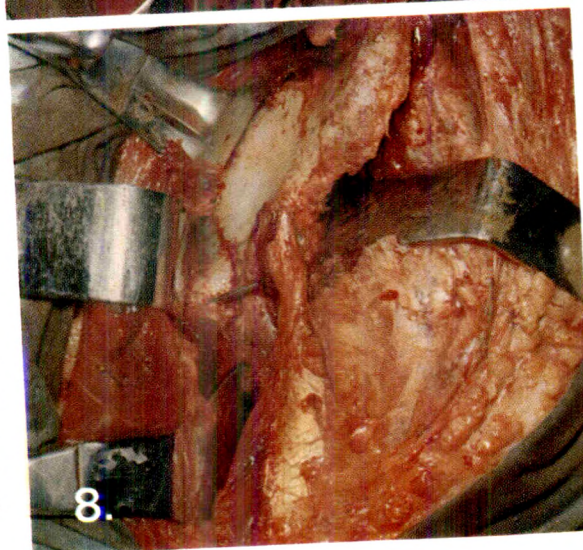


Figure 8. Fracture reduced and fixation secured with screws and staple.



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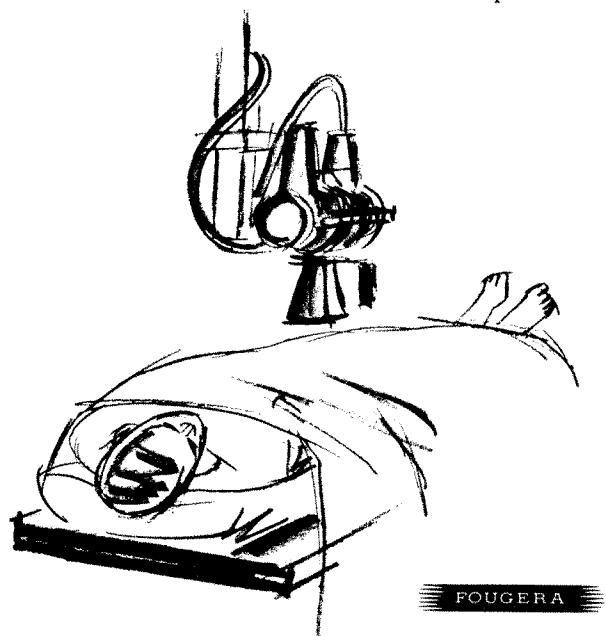
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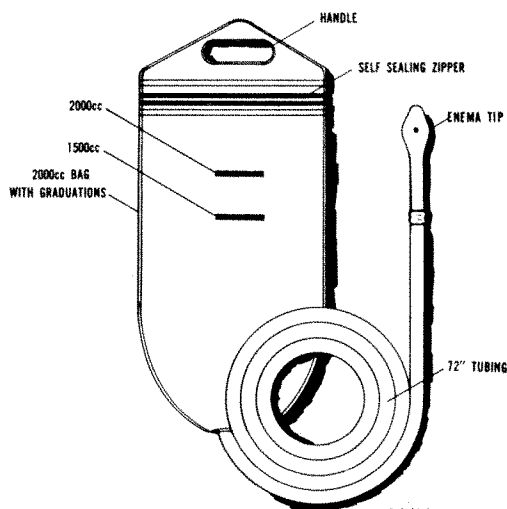
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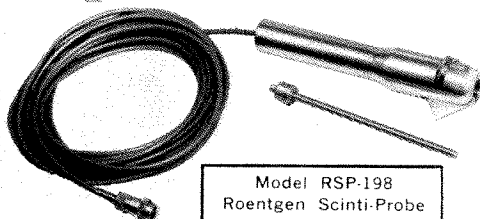
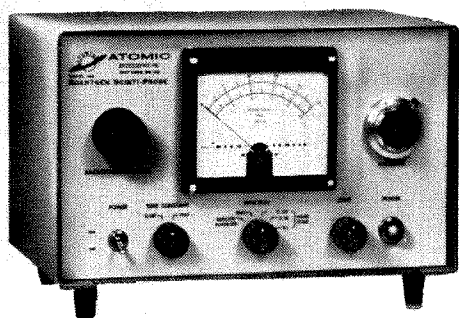
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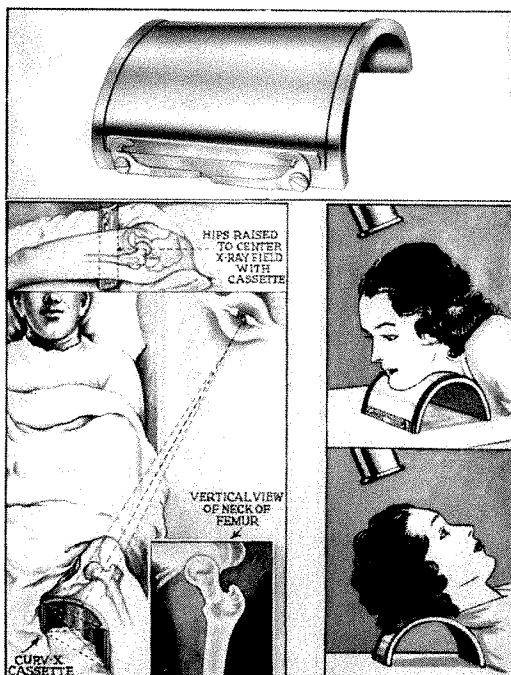
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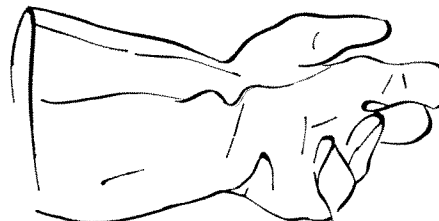
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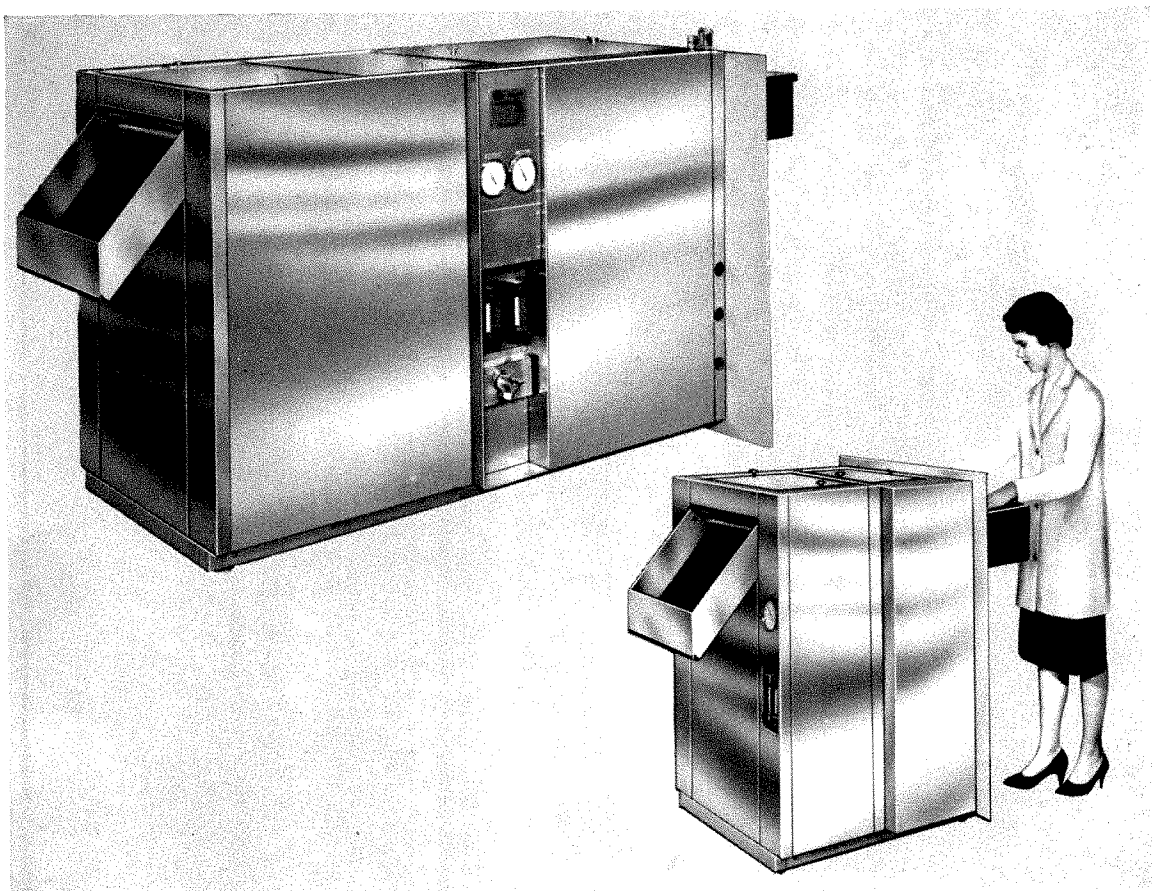
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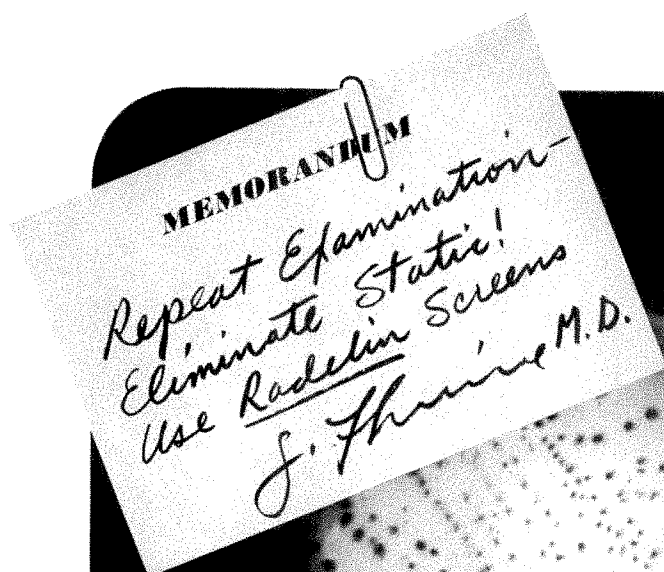
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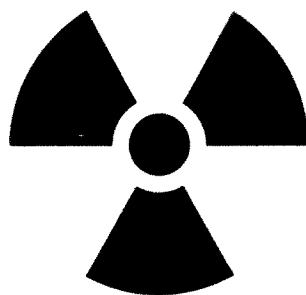
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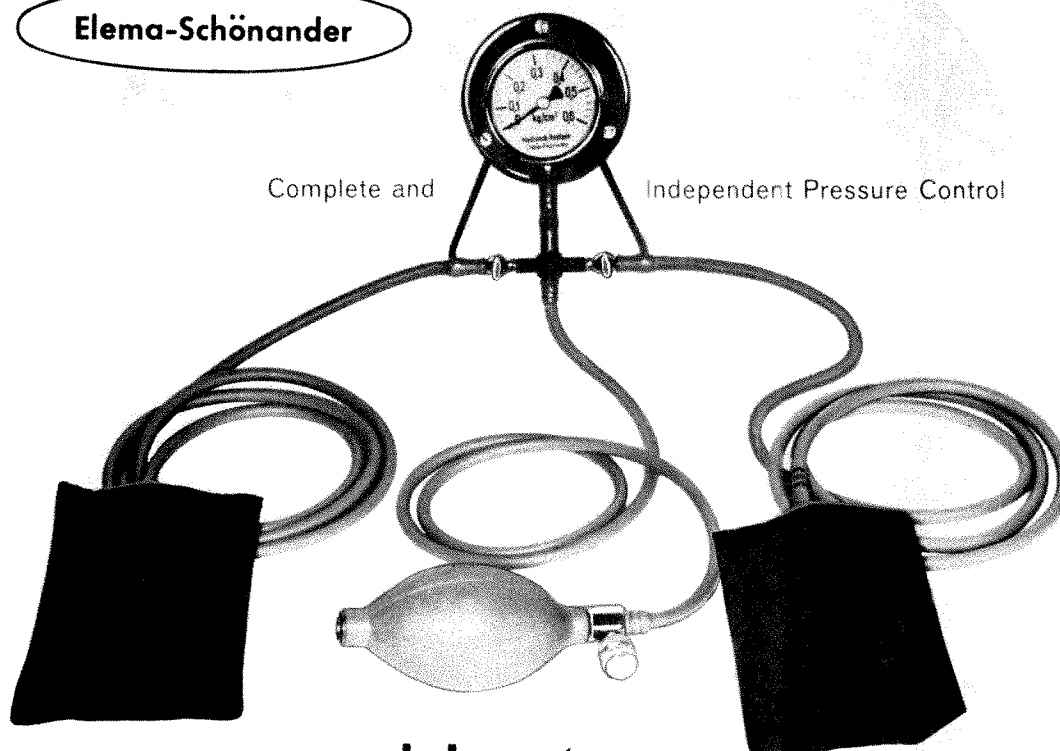
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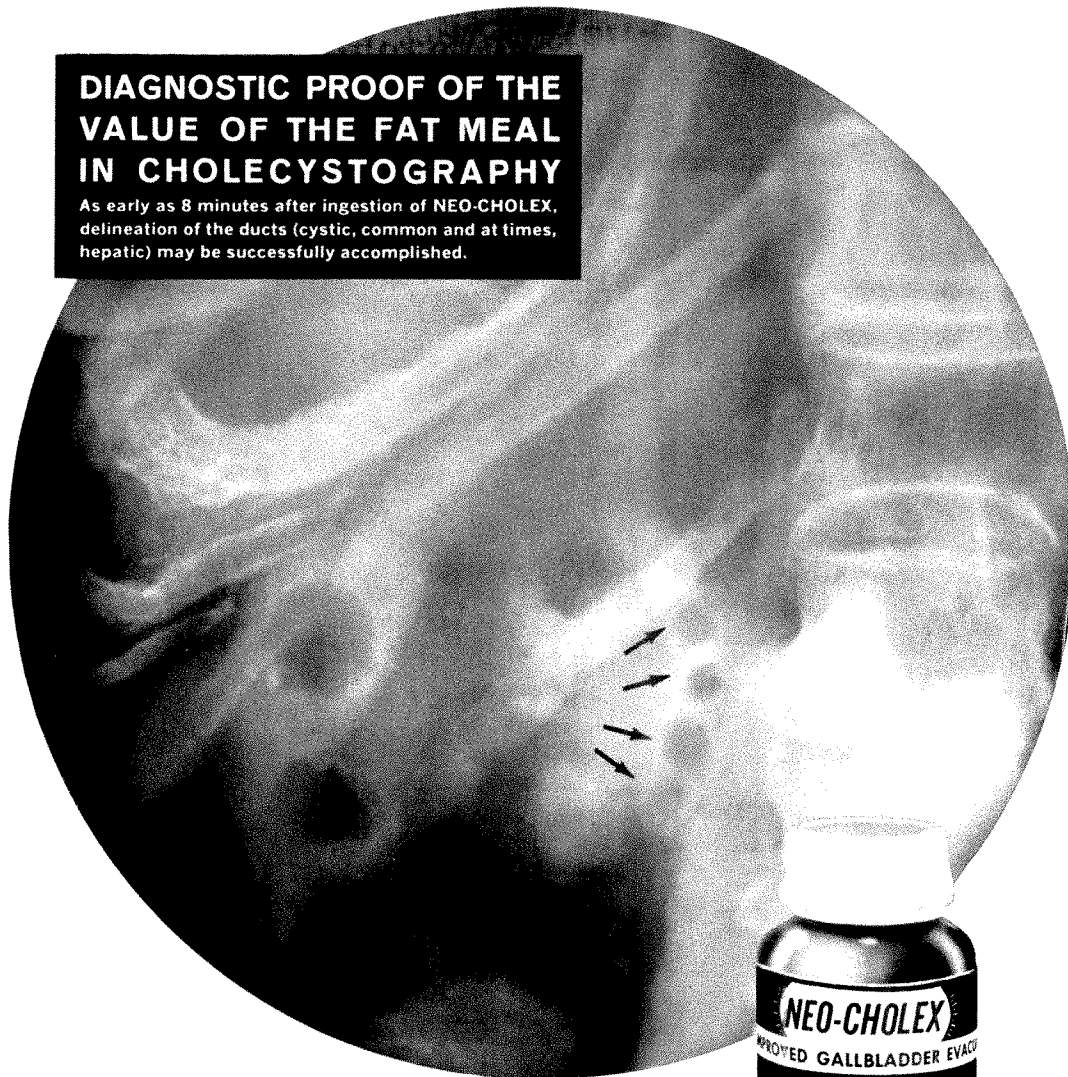
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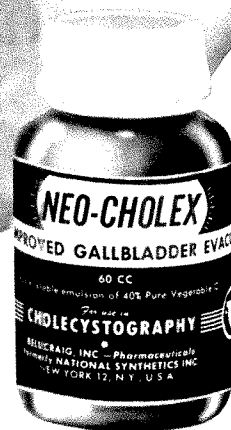


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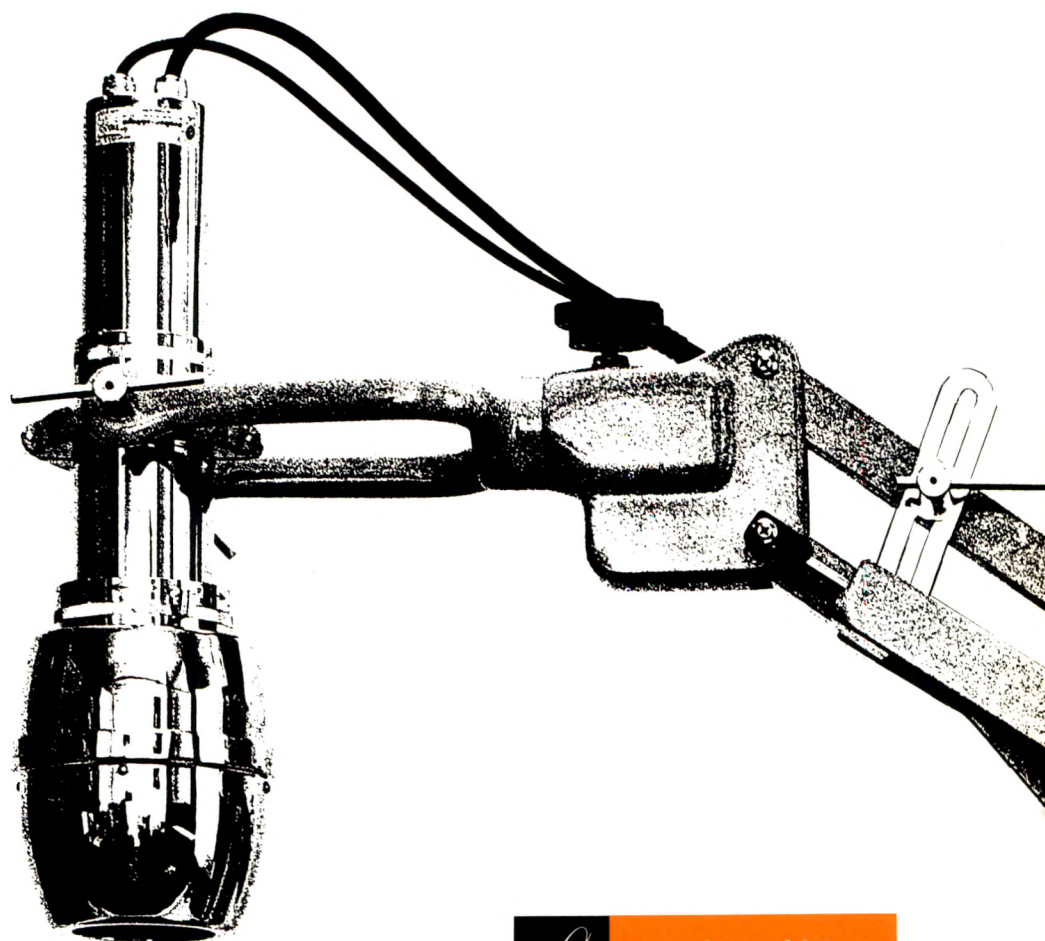
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There have been occasional expressions of doubt as to the need for the fat meal in routine cholecystography. It is to be remembered, however, that today's diagnostic requirements call for detection of abnormalities of the biliary tree, as well as adequate disclosure of gallbladder anomalies, small stones, polyps, etc. The roentgenogram above, exhibiting four stones in the common duct, testifies to the potential efficacy of the fat meal.

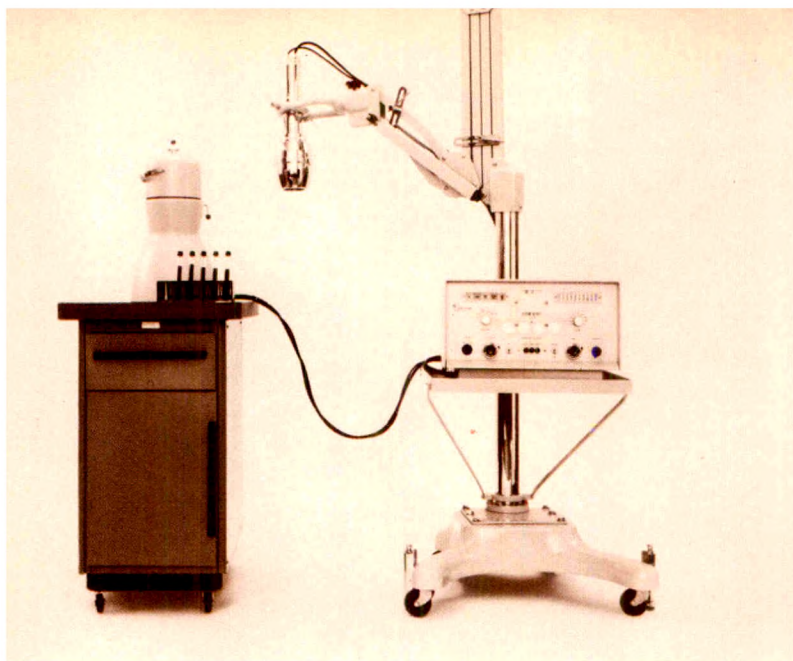
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**MEASUREMENT OF FAT DIGESTION AND ABSORPTION
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MEASUREMENT OF FAT DIGESTION AND ABSORPTION WITH RADIOIODINE LABELLED TRIOLEIN AND OLEIC ACID

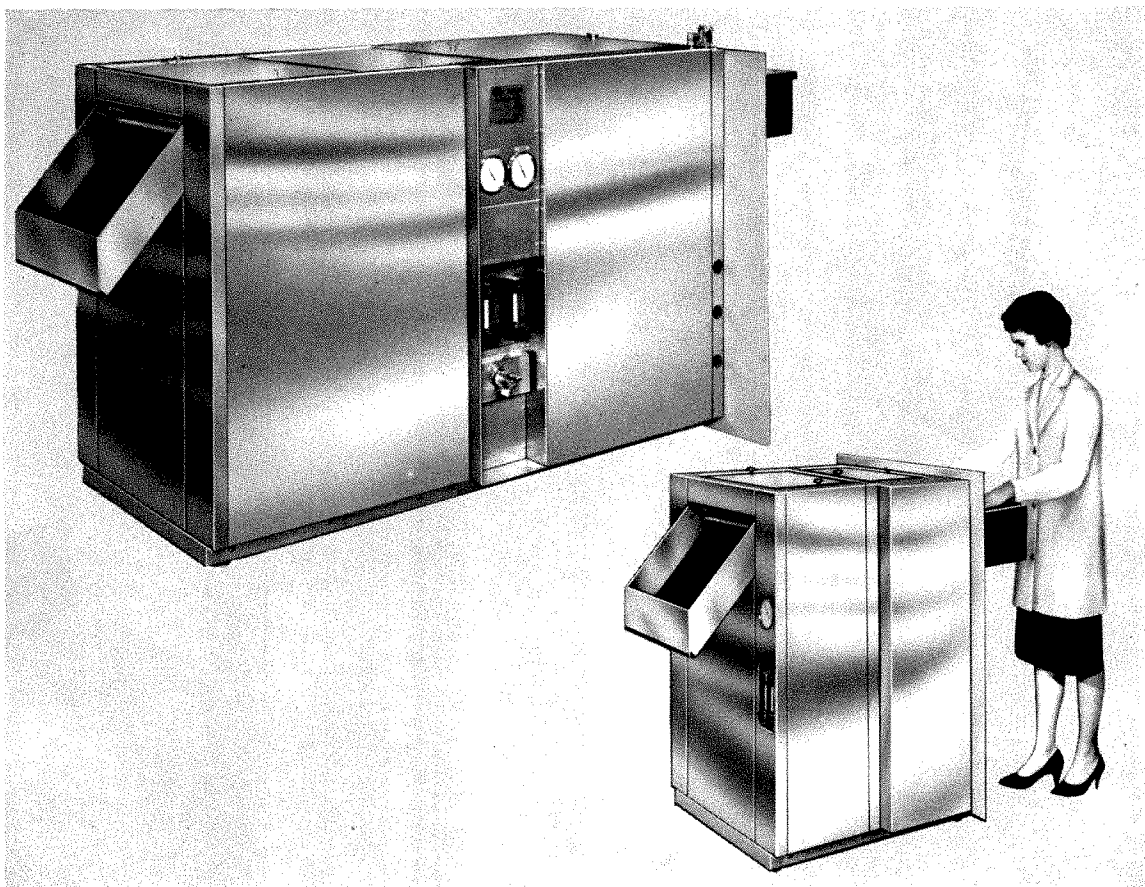
Incomplete utilization of fat in the diet is a frequent accompaniment of diseases of the gastrointestinal tract. The poor utilization can be due to incomplete digestion of the fat due to a lack of the emulsifying effect of bile or the lack of fat splitting enzymes, chiefly those in the pancreatic secretion. In biliary obstruction or pancreatitis, there is an abnormally high fat content in the feces representing unabsorbed fat. Poor utilization may also be due to disturbances in the intestinal mucosa which prevent normal absorption of the digested fat. In sprue, the voluminous fatty stools are apparently due to this cause. Patients with gastrectomies and fast passage time of the intestinal contents may also have poor utilization of dietary fat.

Radioiodine labelled triolein, a fat, and oleic acid, the product of splitting triolein are useful in evaluating fat digestion and absorption. The labelled triolein is administered as a capsule or emulsion in milk and its appearance in the blood stream followed by making counts of the blood at intervals after ingestion of the fat. If the amount which appears in the blood stream is low, labelled oleic acid can be used to differentiate between lack of digestion and poor absorption as the cause. Absence of digestion will not affect oleic acid absorption and a normal appearance curve in the blood is obtained. In patients with abnormalities of the intestinal mucosa or fast passage time, the appearance of the labelled oleic acid in the blood stream will also be below normal limits.

A number of methods for administering the labelled fat or oleic acid have been proposed. It has been long recognized that absorption of fat is strongly dependent on the manner in which it is fed. The original investigators used a 48% emulsion of peanut oil stabilized with Tween 80 as the vehicle for administration. Subsequent investigators have used capsules containing the labelled material, or emulsions in milk.

TYPICAL PROCEDURE

1. Patients are fasted for 6 hours before the test. The test meal consists of one capsule containing 25 microcuries of labelled triolein in a total volume of 0.5 ml. of peanut oil and three capsules each containing 0.5 grams of barium sulfate (x-ray grade). Twenty drops of Lugol's solution are given immediately after the test meal to block thyroid uptake of the radioiodine released during metabolism of the fat.
2. Blood samples are obtained at 4, 5 and 6 hours. The patients are fluoroscoped at 3 hours to make sure of gastric emptying and to confirm the dissolution of the capsules. Feces are collected for 48 hours. There is no restriction of food after the last blood sample is obtained.
3. Appearance of radioactivity
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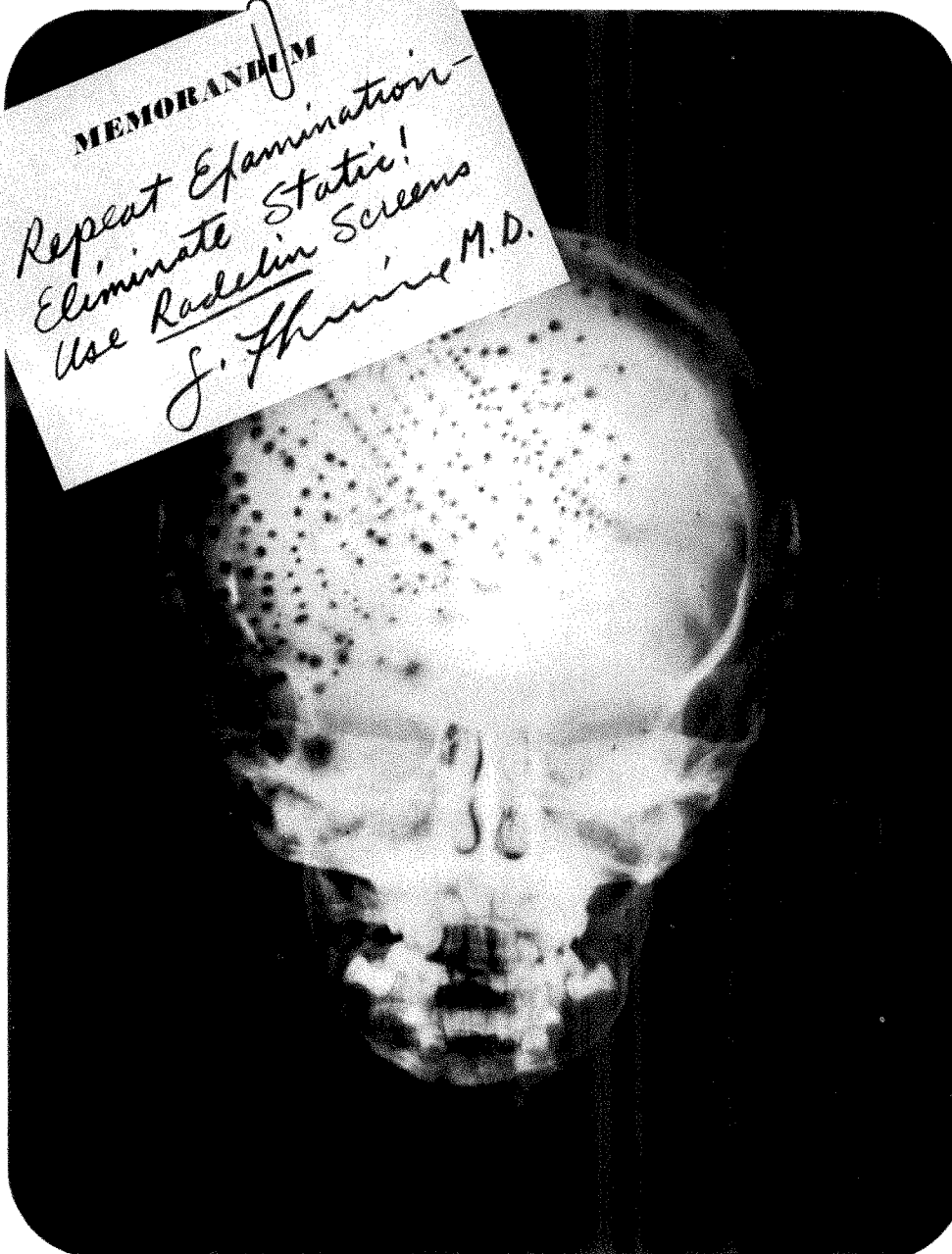


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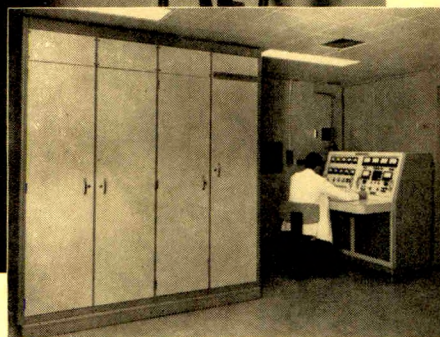
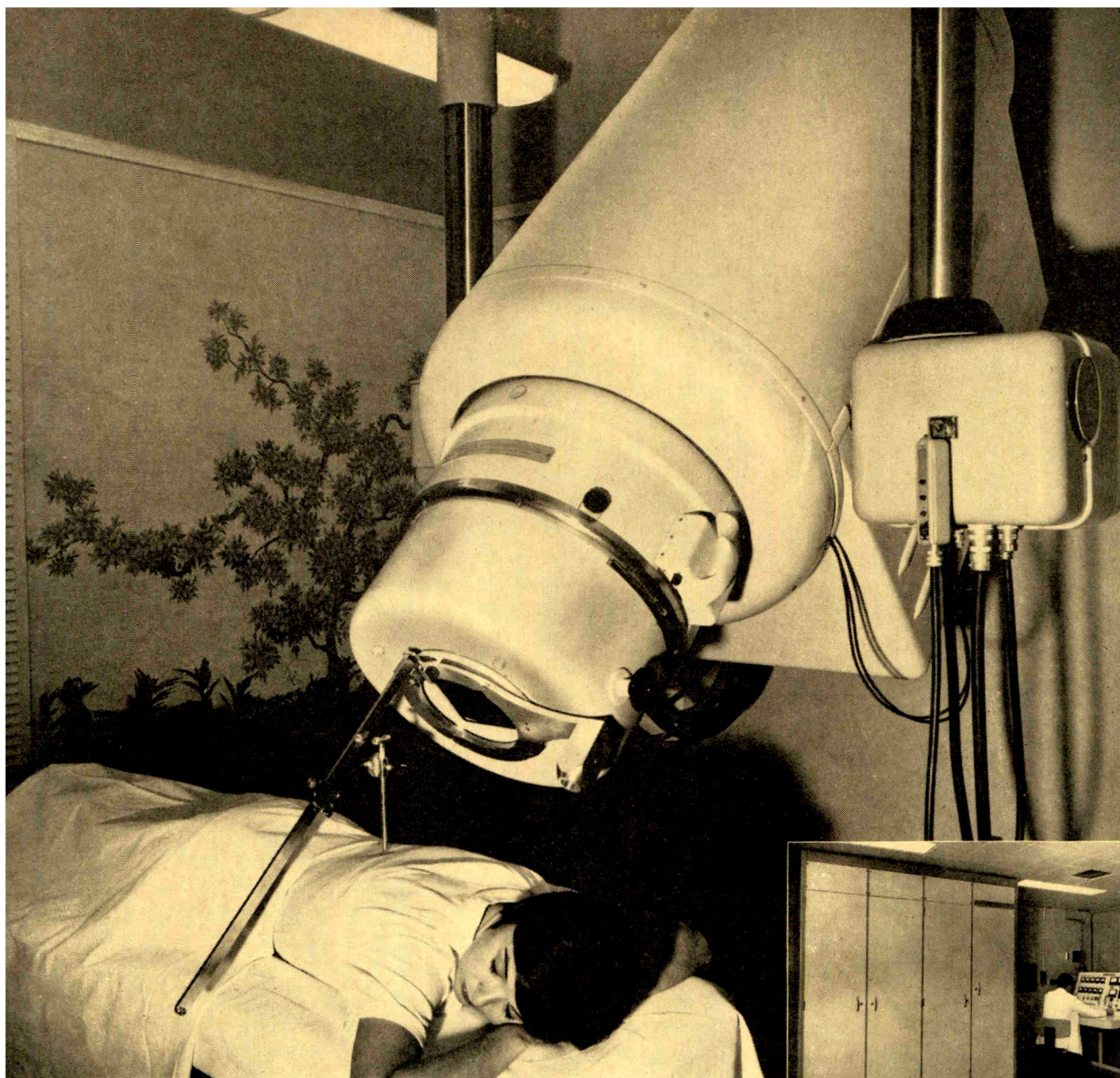
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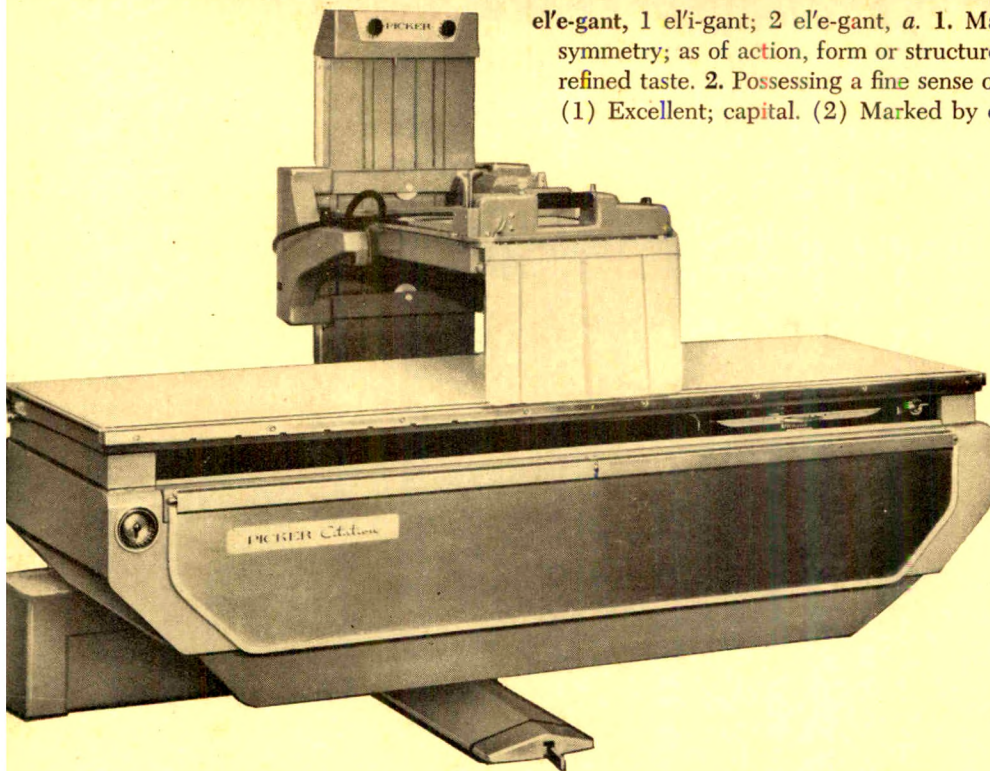


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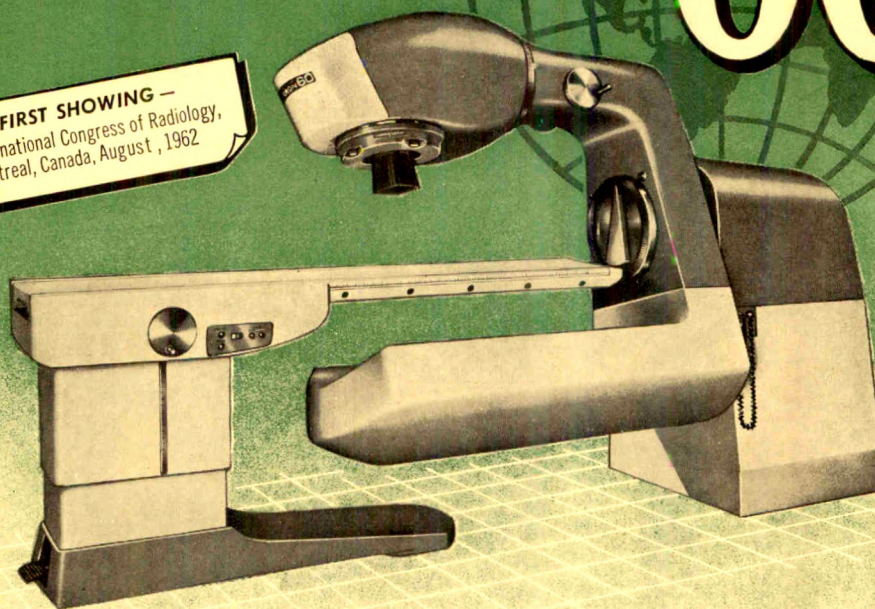
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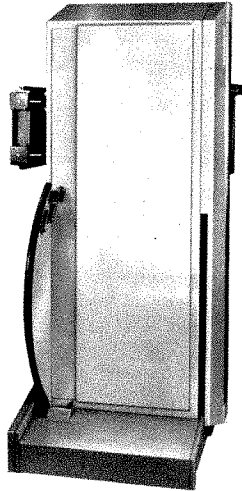
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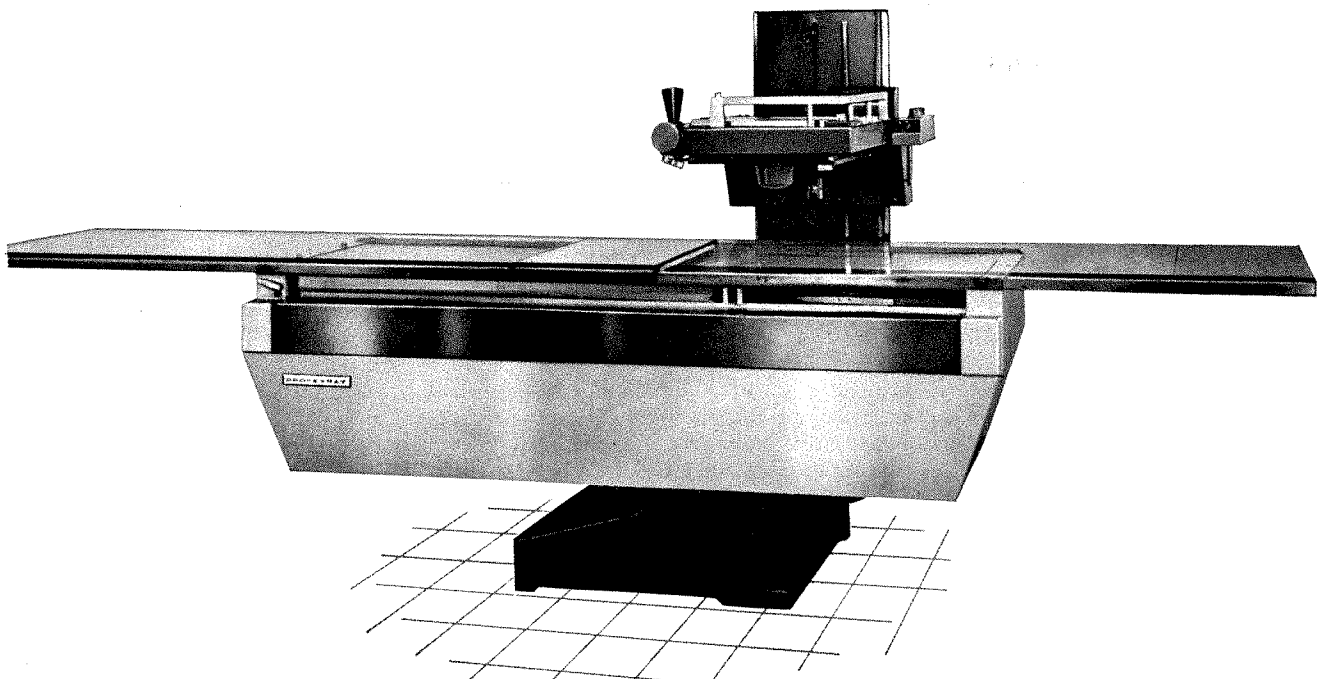
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VOL. 87

May, 1962

No. 5

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- b. The radioactivity administered is determined by making a 1 to 1000 dilution of one of the capsules containing an identical amount of labelled triolein in petroleum ether and counting 3 ml. of the diluted standard in the well detector. Dilution may be made by breaking a capsule in 10 ml. of petroleum ether and dissolving the triolein. A 1 to 100 dilution of this solution in petroleum ether can then be made.
- c. The total amount of radioactivity in the patient's blood volume can be calculated from the following formula which assumes that the blood volume is 7 percent of the body weight.

% I-131 in total blood volume =

$$\frac{\text{cpm in sample} \times 70 \times \text{kg. body weight}}{\text{cpm in standard} \times 1000}$$

4. Fecal radioactivity:

- a. The feces are collected in a standard container.
- b. A probe scintillation detector is positioned 30 cm. from the top surface of the sample container and the radioactivity measured.
- c. A 100 gram homogeneously distributed standard solution containing an amount of radioactivity equal to that ingested by the patient is counted in the same type of container in the same way.
- d. The per cent of the administered dose excreted in the sample of feces is calculated from the data:

$$\% \text{ fat excreted} = \frac{\text{cpm in fecal sample}}{\text{cpm in standard}} \times 100$$

5. The test can also be done with labelled oleic acid in the same way to give information which is helpful in differentiating poor digestion and poor absorption as the etiology of low blood levels and high fecal excretion. Of course, sufficient time must be allowed between the tests to permit excretion of the labelled triolein and a control sample of blood should be obtained before administering the second test meal.

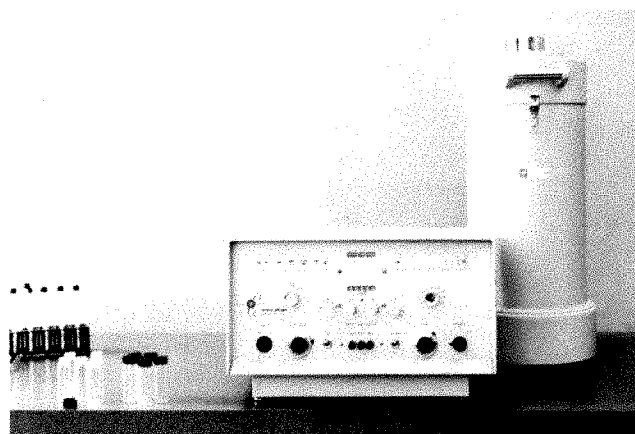
RESULTS

In the normal individual, the plasma radioiodine level rises over a six hour period to reach about 12 per cent of the administered dose. If there is more than 8 per cent in the average of the 4, 5, and 6th hour samples, the results can be considered normal. If there is less than 5 per cent, there is marked impairment of absorption. If the value is between 5 and 8 per cent, there is considered to be moderate impairment.

The normal individual excretes less than 2 per cent of the labelled fat in the feces during the 48 hour period. In impaired fat absorption, the amount is increased and may reach 95 per cent of the dose.

REFERENCES

1. M. M. Stanley and S. J. Thannhauser, *J. Lab. Clin. Med.* 34: 1634 (1949).
2. Kirsner et al., *Gastroenterology* 32: 1 (1957).
3. J. K. Isley et al. *ibid.* 35: 482 (1958).
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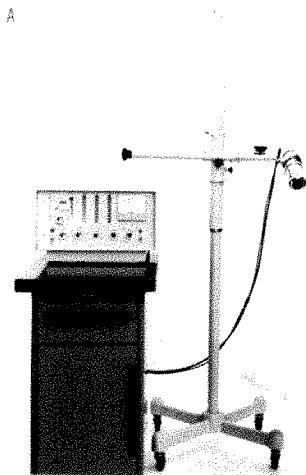


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Measurement of fecal radioactivity is made with the same instrumentation commonly used in thyroid uptake measurements. The SA2 Clinical Stand is ideal for positioning the DS-201 Scintillation Detector at the desired distance from the container.

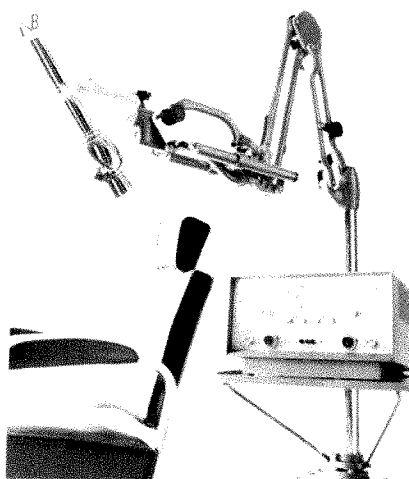


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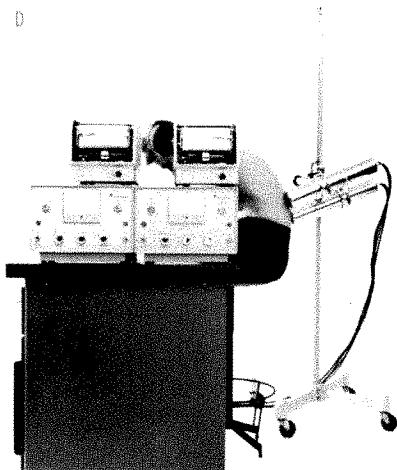
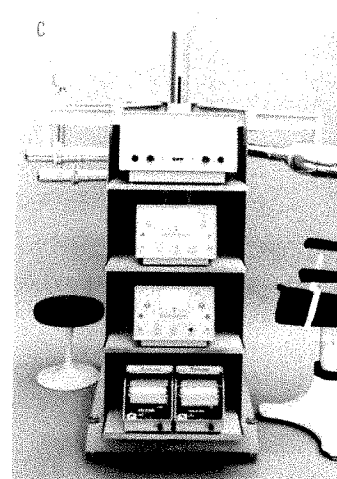
Nuclear-Chicago's extensive line enables the clinician to choose a system specifically designed to meet his needs and budget. Shown above are three complete systems for thyroid uptake measurements and similar applications.

Photograph A illustrates a basic system which combines the 181B Decade Scaler, DS-101 Scintillation Detector, and the SA1 Detector Stand. A second arm and detector can be added to the stand for conversion to kidney function studies as in photograph D.



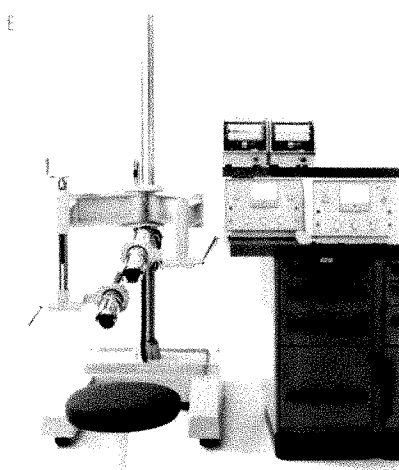
A more versatile single-detector system is shown in photograph B. Here the DS-201 two inch crystal Detector is mounted on the SA2 Detector Stand which provides a shelf for the 132B Scaler/Spectrometer or other clinical scaler.

Nuclear-Chicago's most versatile *in-vivo* system (C) includes the DS-301 three inch crystal Detector and 132B Scaler/Spectrometer for thyroid uptake measurements. Two additional arms and probe detectors, two ratemeters, and two recorders are provided for kidney function studies.



Nuclear-Chicago's basic kidney function system is shown in photograph D. It consists of two DS-101 Detectors, two 1620BS Ratemeters, two R1000A Chart Recorders, and the SA1 Stand equipped with a second arm. A more versatile system is shown in photograph E. Here the 1710 Stand is used instead of the SA1. A motor in the center column automatically raises or lowers the arms to the desired position. This system can be expanded as the needs of the laboratory increase. An instrument rack and third arm can be added as shown in photograph C.

Nuclear-Chicago offers the most advanced system commercially available for scanning body areas for radioisotope concentrations. The 1705 Dual Scanner shown in photograph F with the DS-301 Scintillation Detector and 132B Scaler/



Spectrometer provides both printed and photographic records of the distribution of radioisotopes in body organs. The 1705 has been successfully used in brain, kidney, thyroid, and liver scanning. The system can be used in thyroid uptake measurements by merely changing collimators.

Complete descriptions of instruments shown here can be obtained by writing for General Catalog S.



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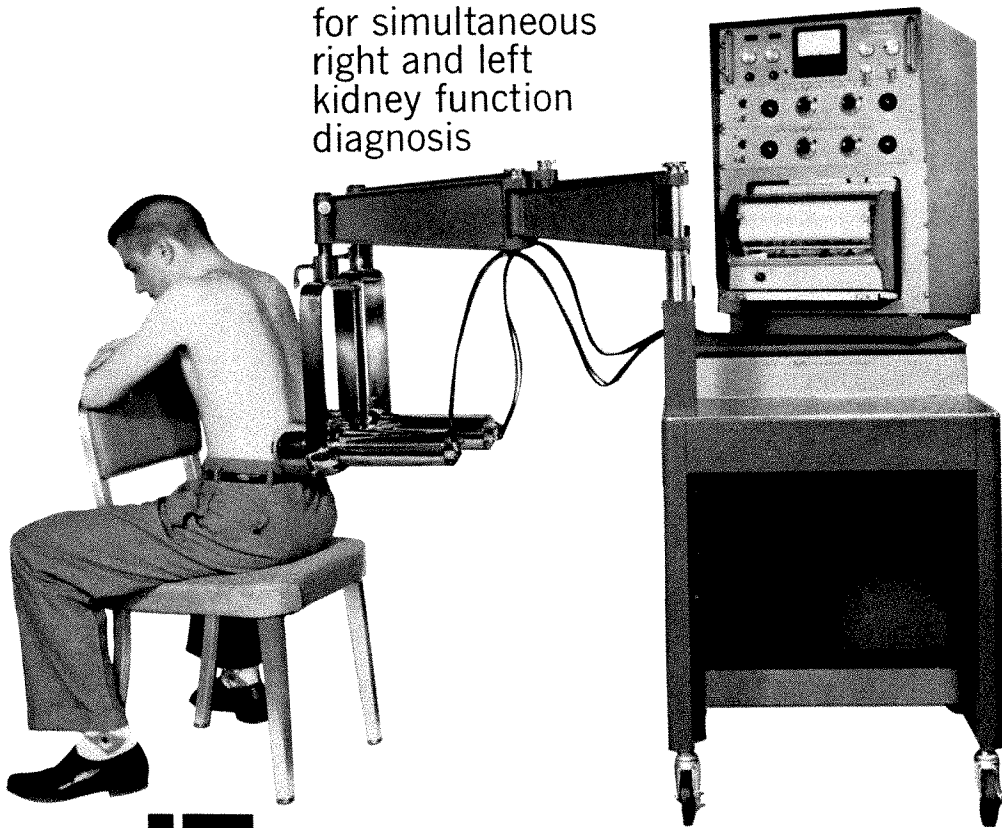
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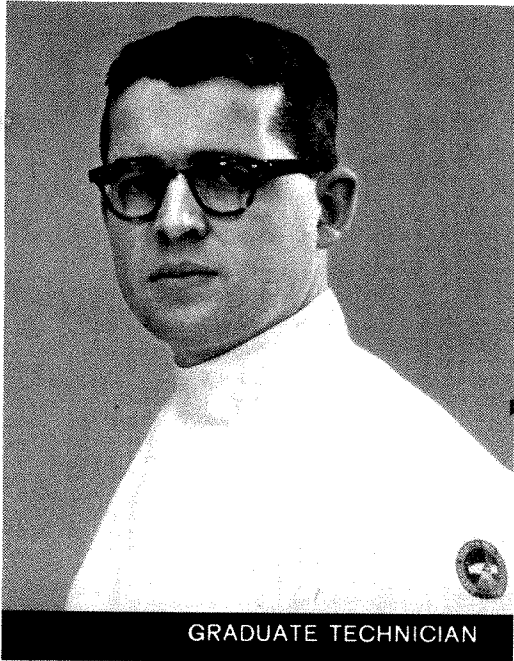


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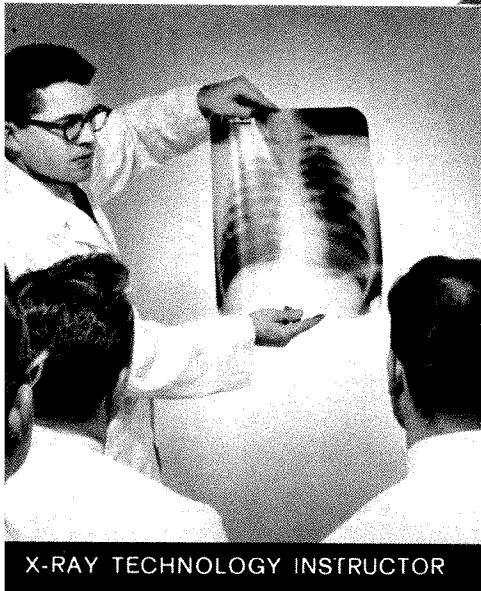
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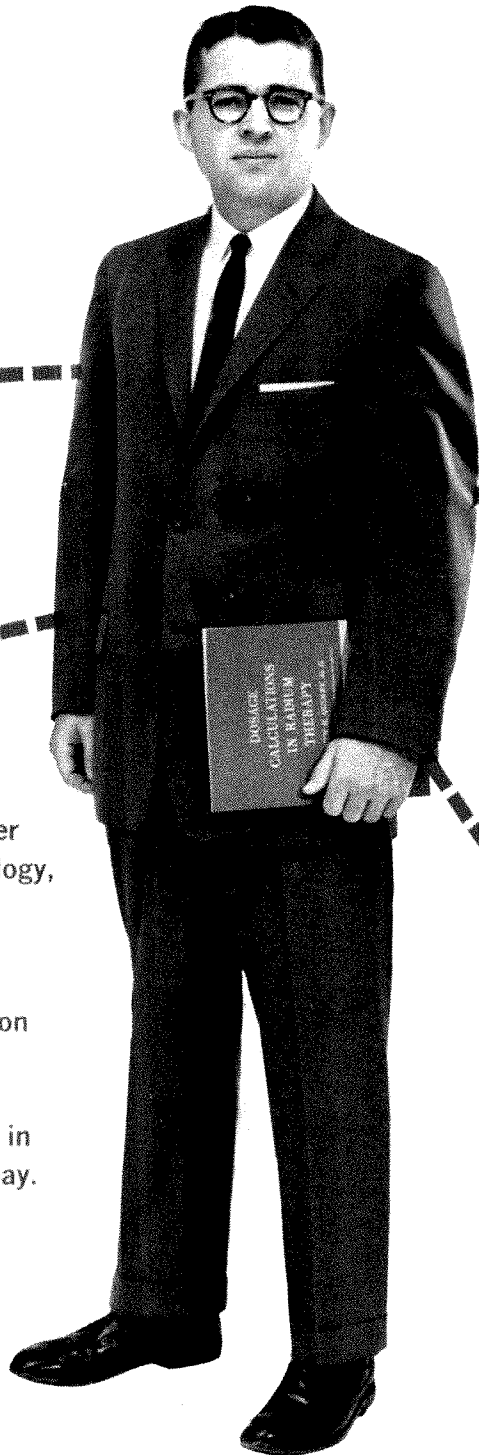


GRADUATE TECHNICIAN

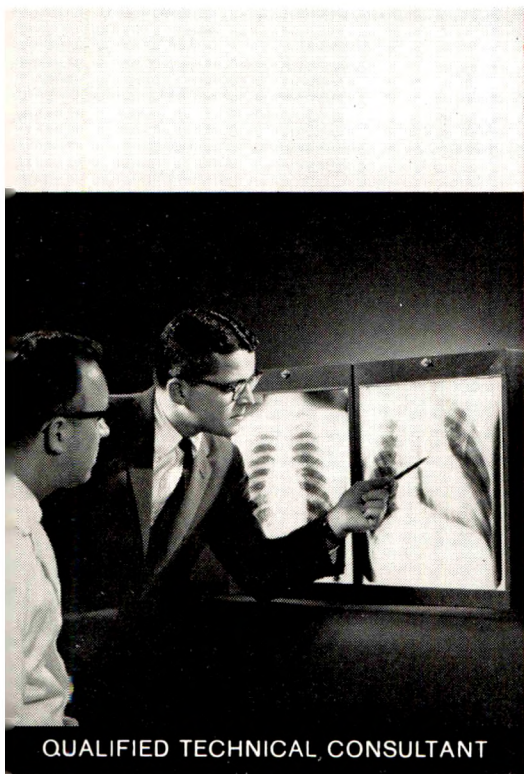


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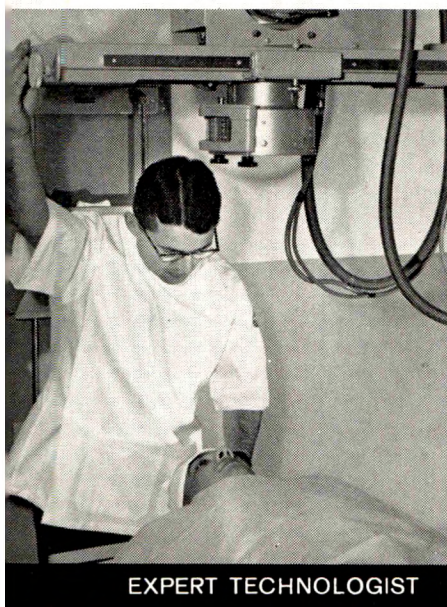


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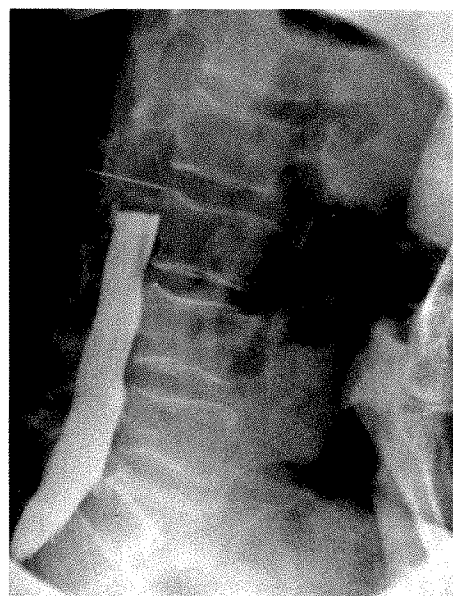
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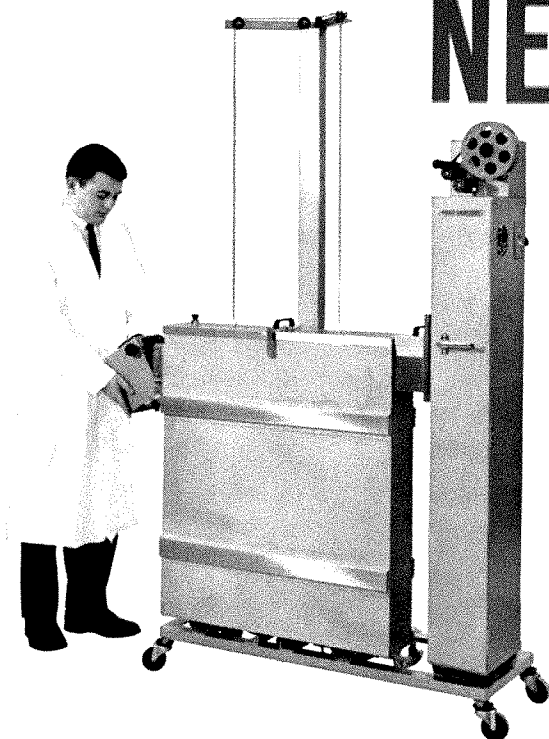


Dynamic Myelography

These two radiographs of the same patient demonstrate the bulging of the annulus fibrosus during hyperextension and flexion, respectively, of the vertebral column. 30 cc of *Pantopaque* contrast medium was used. Note how this technique permits visualization of the posterior surface of the vertebral canal.



“PANTOPAQUE” is the registered trademark under which all leading x-ray dealers supply the compound ethyl iodophenylundecylate, which is synthesized by the Research Laboratories of Eastman Kodak Company and prepared as the myelographic contrast medium *Iophendylate Injection, U.S.P.*, by Lafayette Pharmacal Inc. The trademark serves to indicate to the radiologist continuity of experience in the manufacture of this medium.



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filmstrip travels in light-trapped
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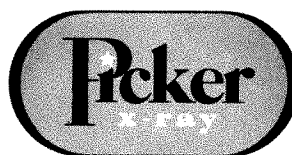
adjustable dwell period
in developer or any other solution

alterable ***processing sequence***

inserts (unlike fixed compartments)
can be arranged in any order

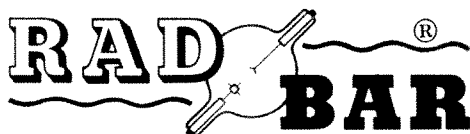
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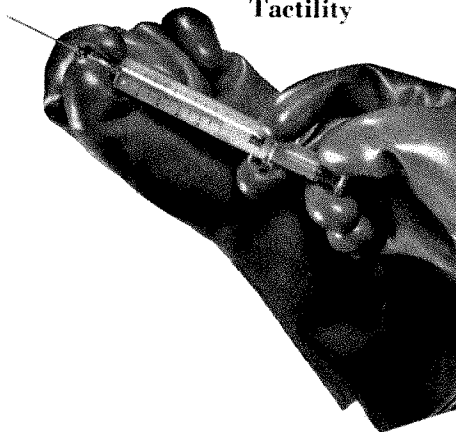
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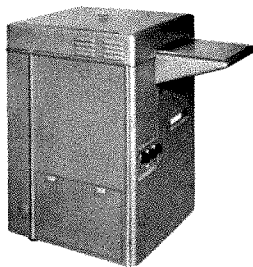
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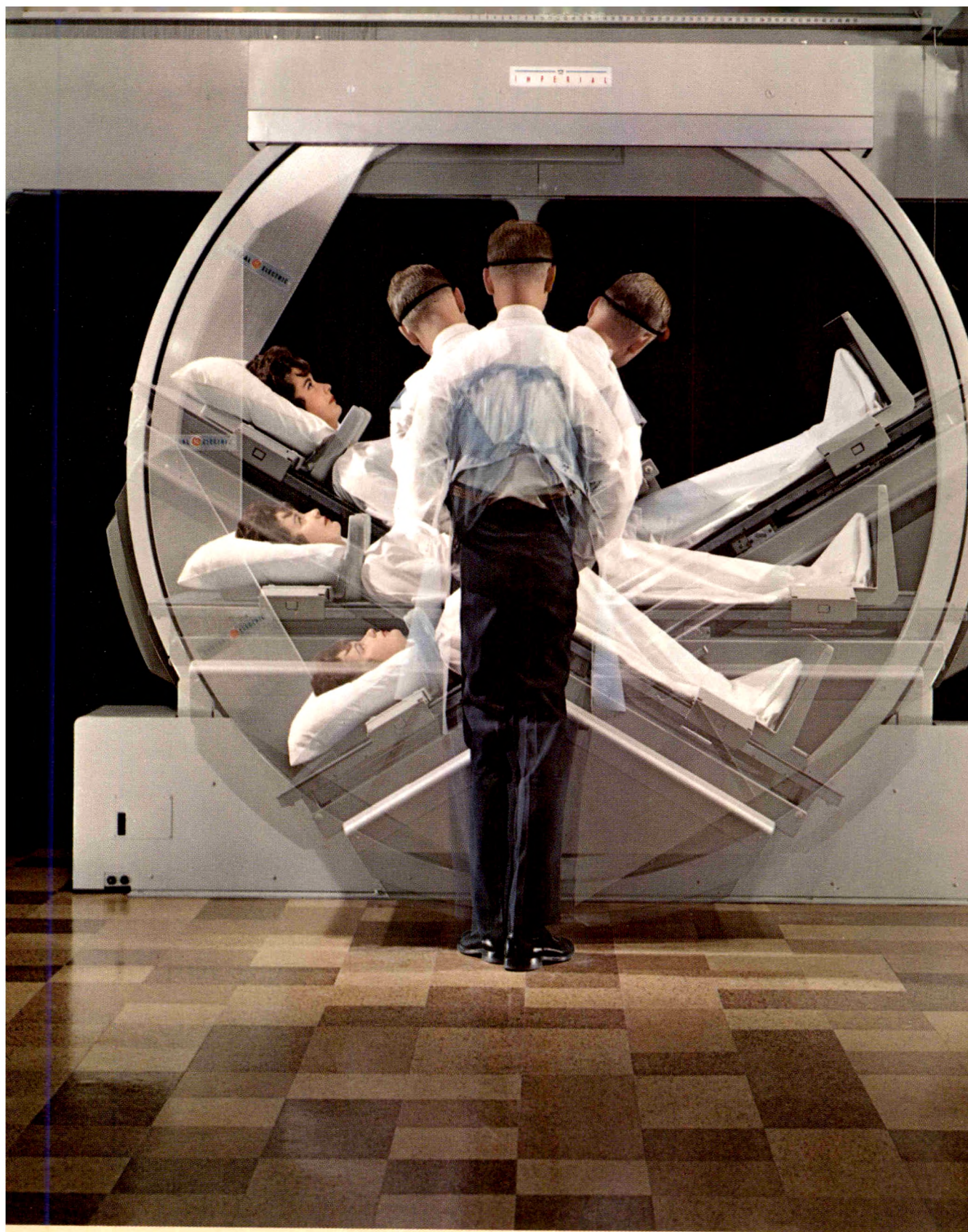
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. . . even during difficult procedures. An Imperial II diagnostic x-ray installation is oriented to the radiologist. This stop-motion color photo provides a graphic example: with ring-mounted pivoting, screen-to-eye relationship remains practically constant and centered . . . spot-film device neither advances nor recedes as table is tilted.

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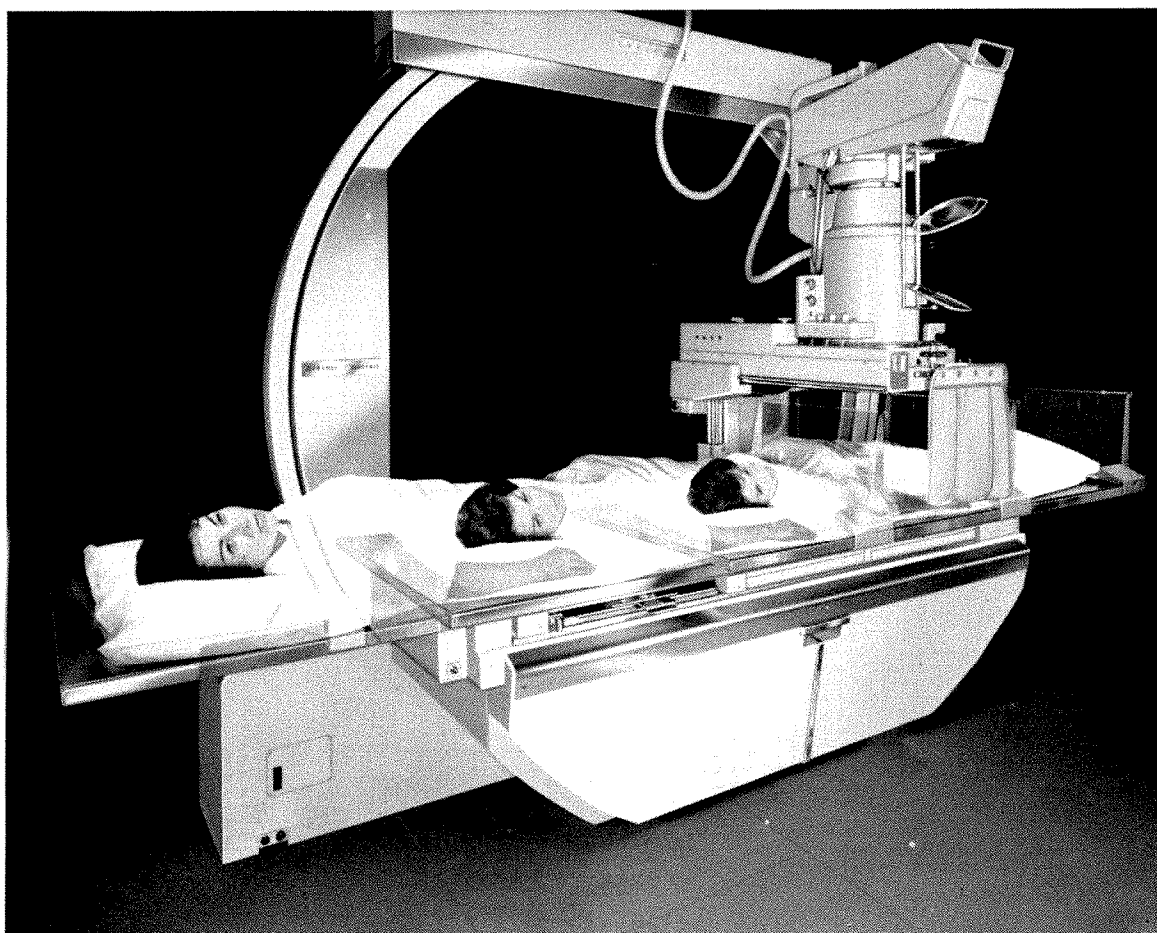
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. . . permits you to move patient and table laterally — without hands, without effort — without disturbing the position of the screen. Superbly balanced lateral shift is the reason for this handling ease . . . another almost-automatic way Imperial responds to your every touch.



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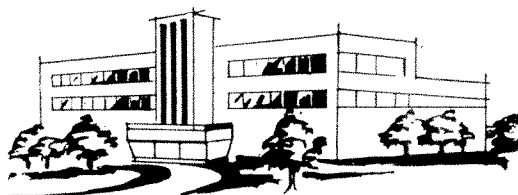
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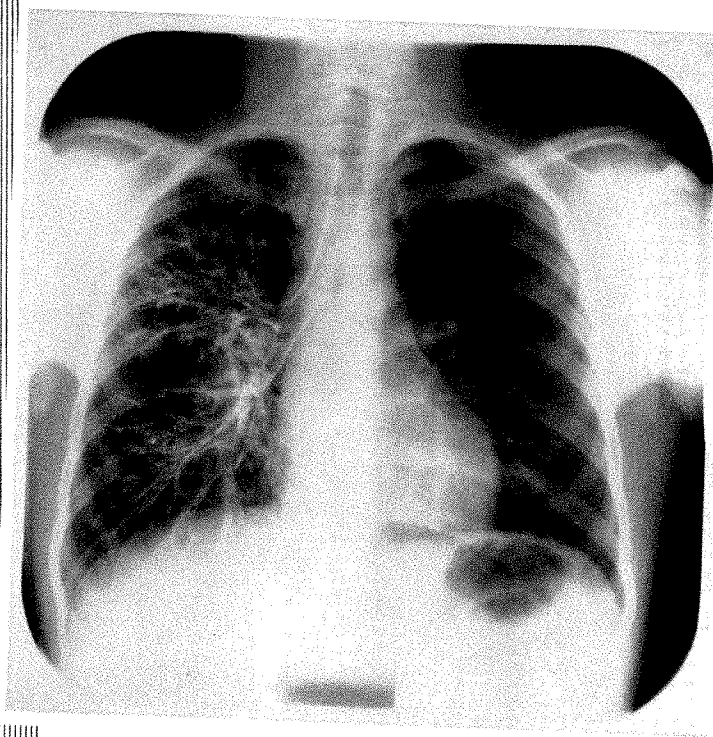
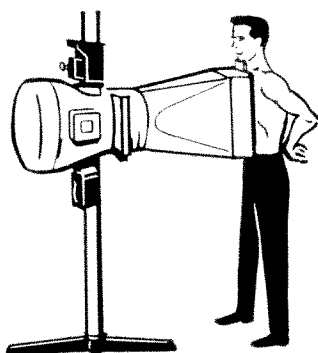
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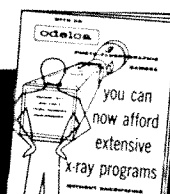
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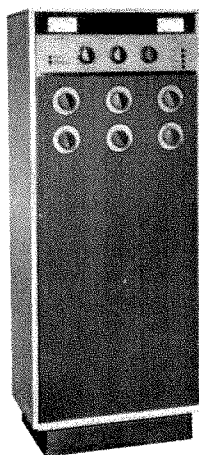
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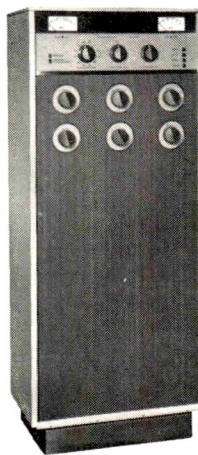
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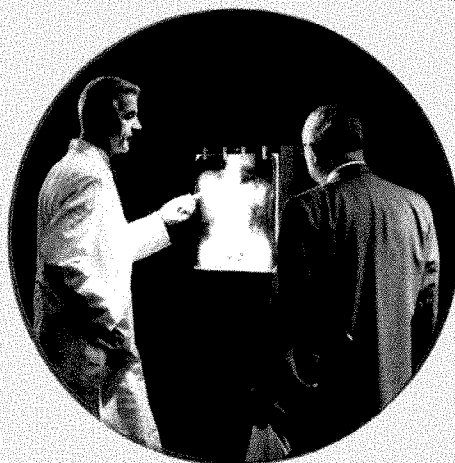
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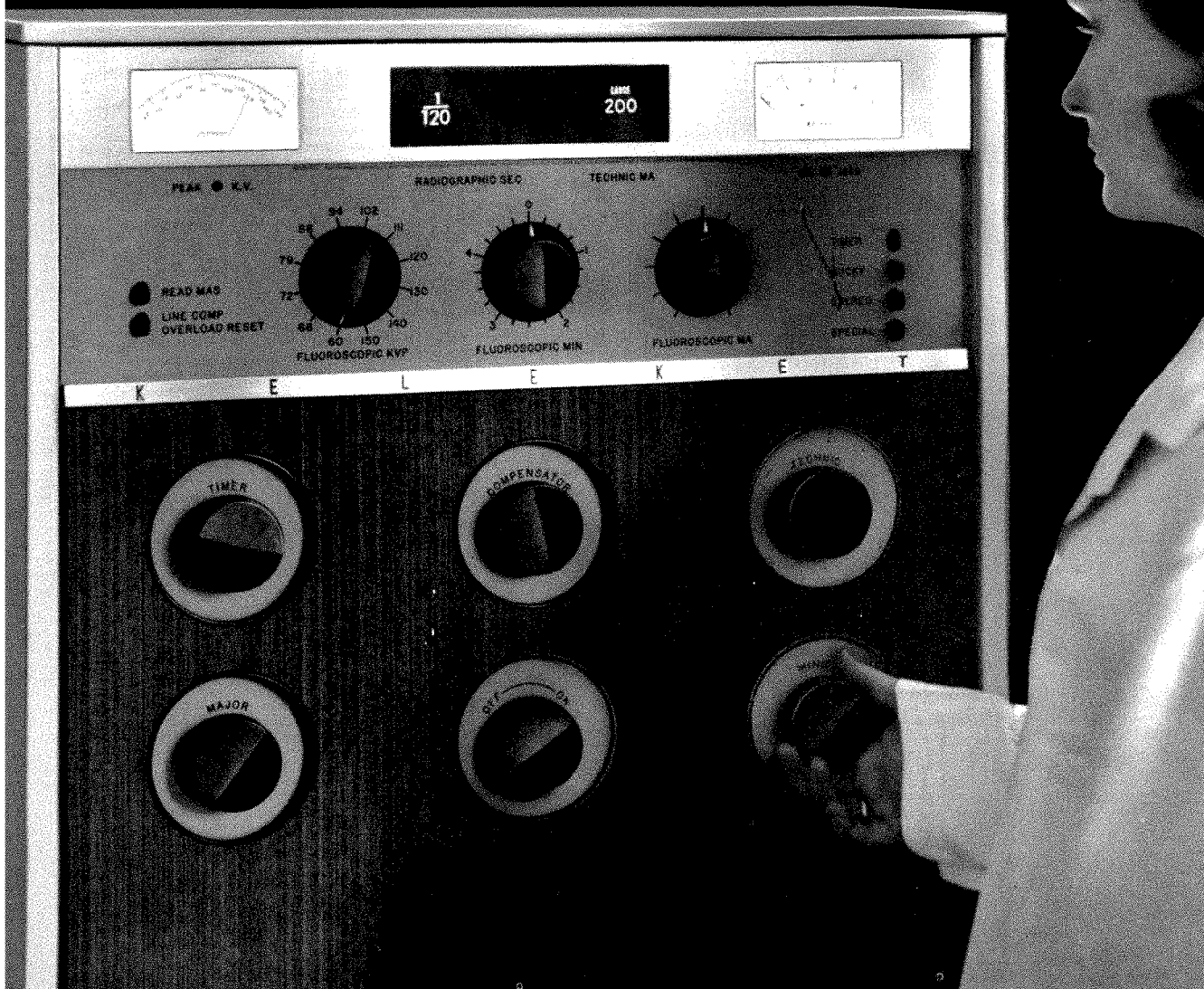
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- (3) In-Wall Wet-Film model.

This unit is designed to process radiographs quickly and economically at a cost any consumer can afford to pay.

Wet radiographs, fixed but not washed can be viewed in 3 minutes—fixed and washed in 6 minutes after the dry film is placed in the developer.

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X-RAY NEWS

No. 56



Photo A ▲

A Table for Magnification Radiography

by Dale H. Boven, R.T. (ASXT)
Hackley Hospital, Muskegon, Michigan

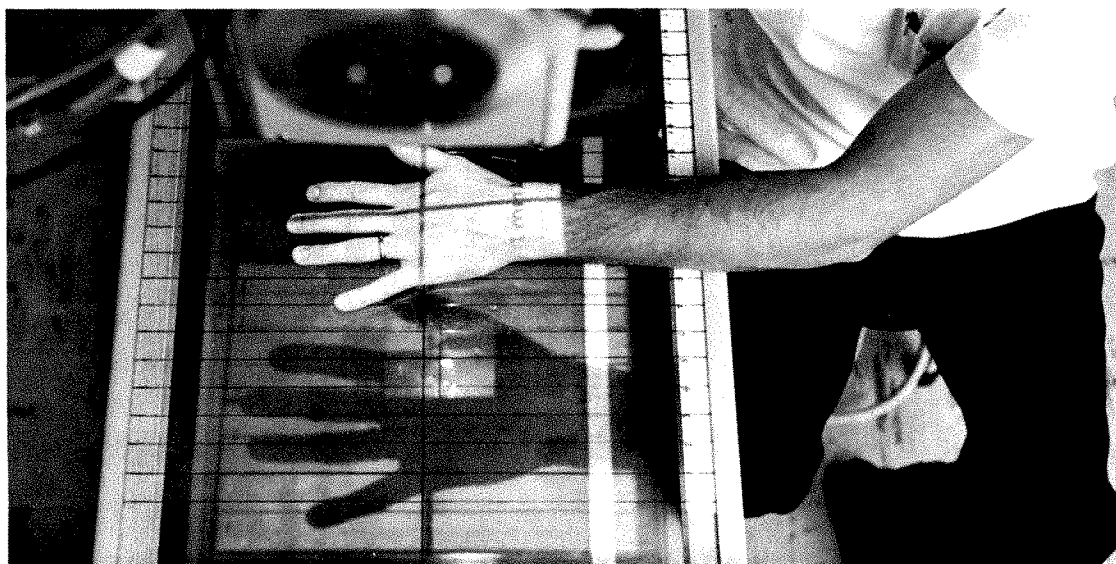
The use of magnification in the diagnosis of the radiographic image can be of great advantage, especially in suspected hairline fractures and certain pathological conditions.

An easier method of more accurate positioning for this type of radiography is possible by the construction of a simple but special type of table (Photo A) to be used as an extension of any radiographic table or stretcher.

Before construction of the table (which will be described), determine whether or not it will be adaptable to your present radiographic room. Be sure the x-ray tube carriage will extend to the head of the new table after it is placed at the end of the present radiographic table. With an overhead crane-type tube carriage there should be no difficulty using the table extension either with the radiographic table or the stretcher.

The frame of the table may be constructed of wood, preferably a number one grade of 2 x 2 lumber. The height and width should be the same as the radiographic table and should be at least 40 inches in length.

▼ Photo B



OVER ►

The top is constructed of $\frac{1}{4}$ -inch-thick transparent LUCITE,* recessed into the table top frame. This thickness is necessary to withstand the weight of heavy patients. The clear LUCITE is utilized not only for transparency, but also for its radiolucency.

Below the table top there is an adjustable shelf upon which the cassette or film holder is placed.

It is absolutely essential that the parts to be magnified, the x-ray tube, and the film be in accurate alignment. If these three points are out of alignment, it will affect the position of the image on the film to a much greater degree than on a conventional radiograph. This is the primary reason for the construction of this type of table. The transparent table top provides for easy, quick visual alignment of the tube, part, and film.

For accurate positioning it is recommended that the x-ray tube and the film be positioned first. With the use of a collimator-type apparatus adapted to the x-ray tube, the correct tube-film alignment is more readily acquired. The cross hairs and the lighted x-ray field emitted through the clear table top (Photo B) provide for easy visual alignment of films and desired field size.

X-rays follow some of the same laws as light. For example, if the part to be radiographed is an extremity and is placed on the table top between the collimator and the film, the magnified size and outline of the part will be visible on the film holder in the form of a shadow. This, of course, will also show you the size of the image on the finished radiograph. In magnification radiography of the vertebral column, internal organs, and head, the proper centering of the desired part to the pre-positioned tube and film is more difficult. Because of the surrounding tissue, the shadow is not visualized on the film, thus there must be absolute accuracy when centering over the desired part.

When employing magnification radiography, one must utilize the ultra-small focal spot (0.3 x 0.3 mm in size) to avoid any loss of detail. It has been found that a 20-inch focal-table and a 20-inch table-film distance produce the most satisfactory radiographs in this type of work. This, however, may be varied to suit the individual needs.

When radiographing larger parts, a grid cassette or bucky should be used. If a portable bucky is available, it can be placed on the lower shelf provided for the film. When using par speed screens and regular film it is necessary to increase the MAS and KV over conventional techniques.

When using a 0.3 mm size focal-spot, only very limited amounts of MAS can be used. If 20 MA is used at 80 KV, for instance, the exposure time is limited to approximately two seconds. 10 or 15 MA is most commonly used and may be used in the lower KV ranges at the longer exposures. Always refer to the tube rating charts provided by the manufacturer.

Due to the long exposures used, it is necessary that the patient or part be well immobilized in order to obtain good detail.

*Du Pont registered trademark for its acrylic resin.

Tips for Technicians

A Simple Solution for Static Electricity

by Michael Meisner, R.T.
Summit Park Sanitorium
Pomona, New York

Static electricity can be a persistent and annoying problem in an x-ray lab—drawing dirt into the cassettes, making films hard to separate, causing tree-like streaks of exposure on the undeveloped film, making scratches almost unavoidable.

We tried various solutions to this problem, all without conspicuous success. Then one experiment seemed to improve the problem of static electricity. It was a simple step. We grounded the pass box. Instantly, we noticed a difference. Much of our static electricity disappeared, thus reducing the problems we had with dirt, scratching, film separation, and those static exposure streaks that are so annoying.

Grounding, incidentally, is easily accomplished by running a medium-size wire—for instance No. 12—from a screw or other metal part of the pass box to the nearest water pipe. Make sure your wire is touching clean metal at both ends and your static problem is over!



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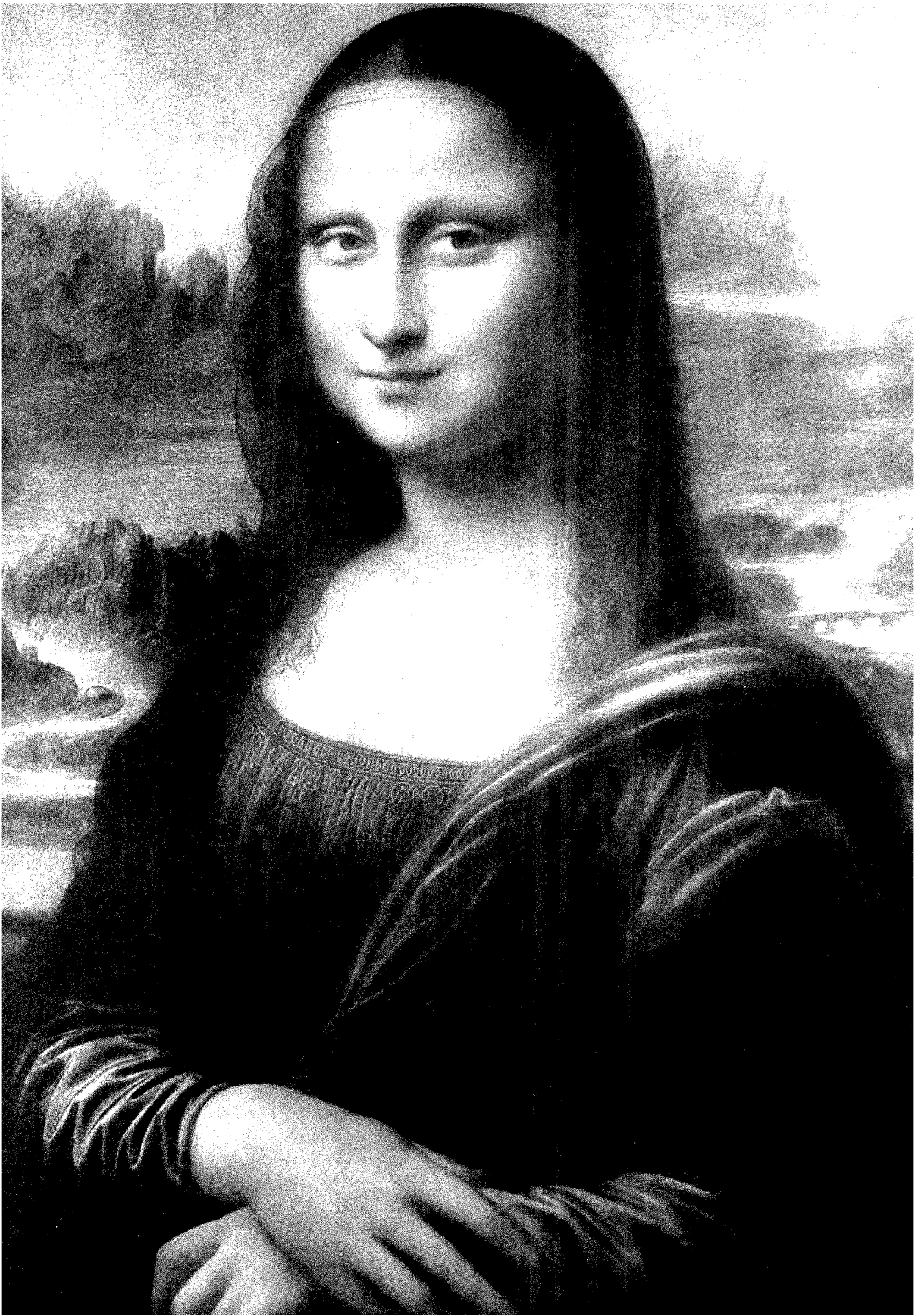
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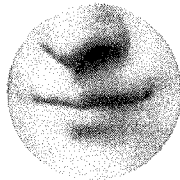
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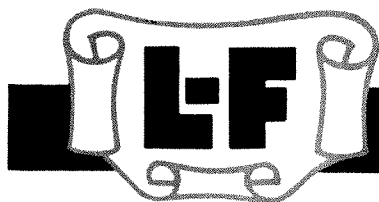
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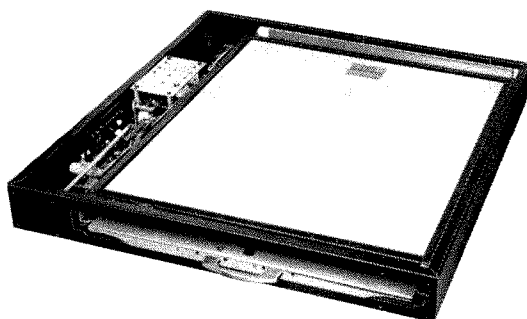
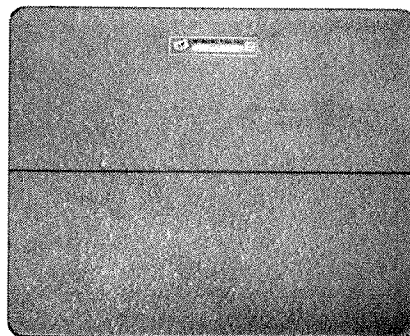
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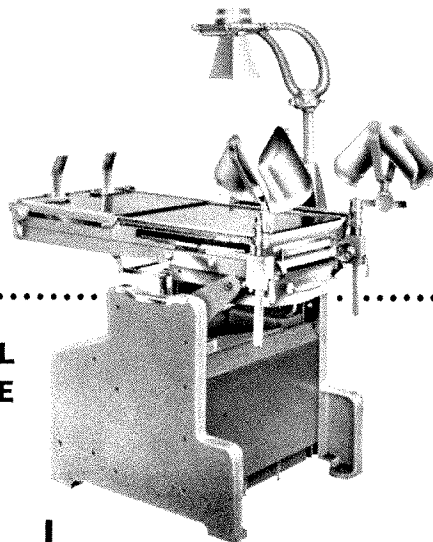


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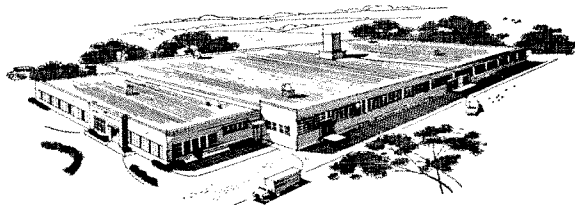
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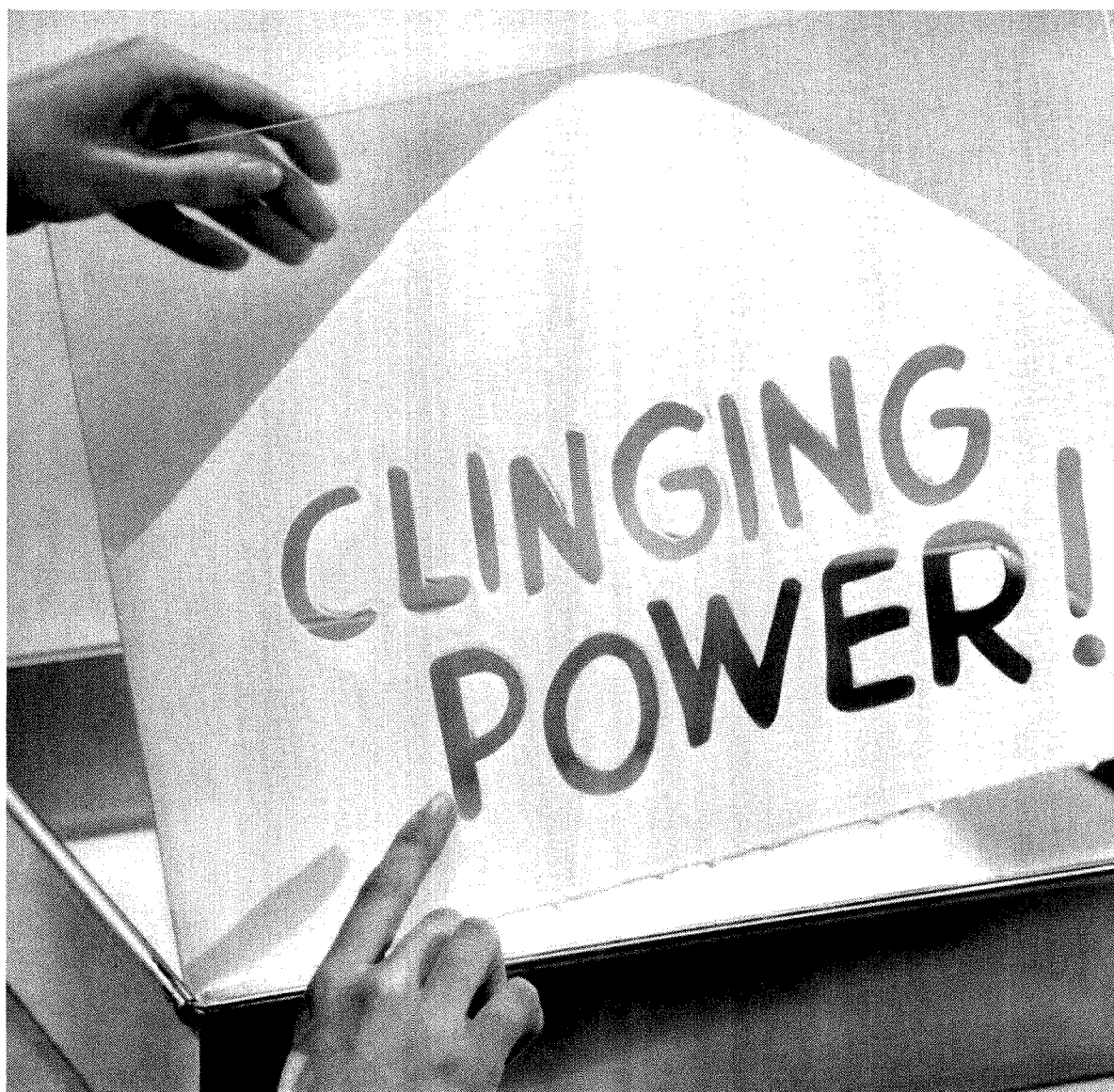


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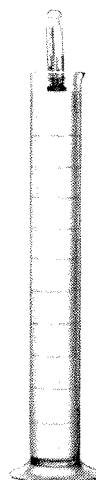
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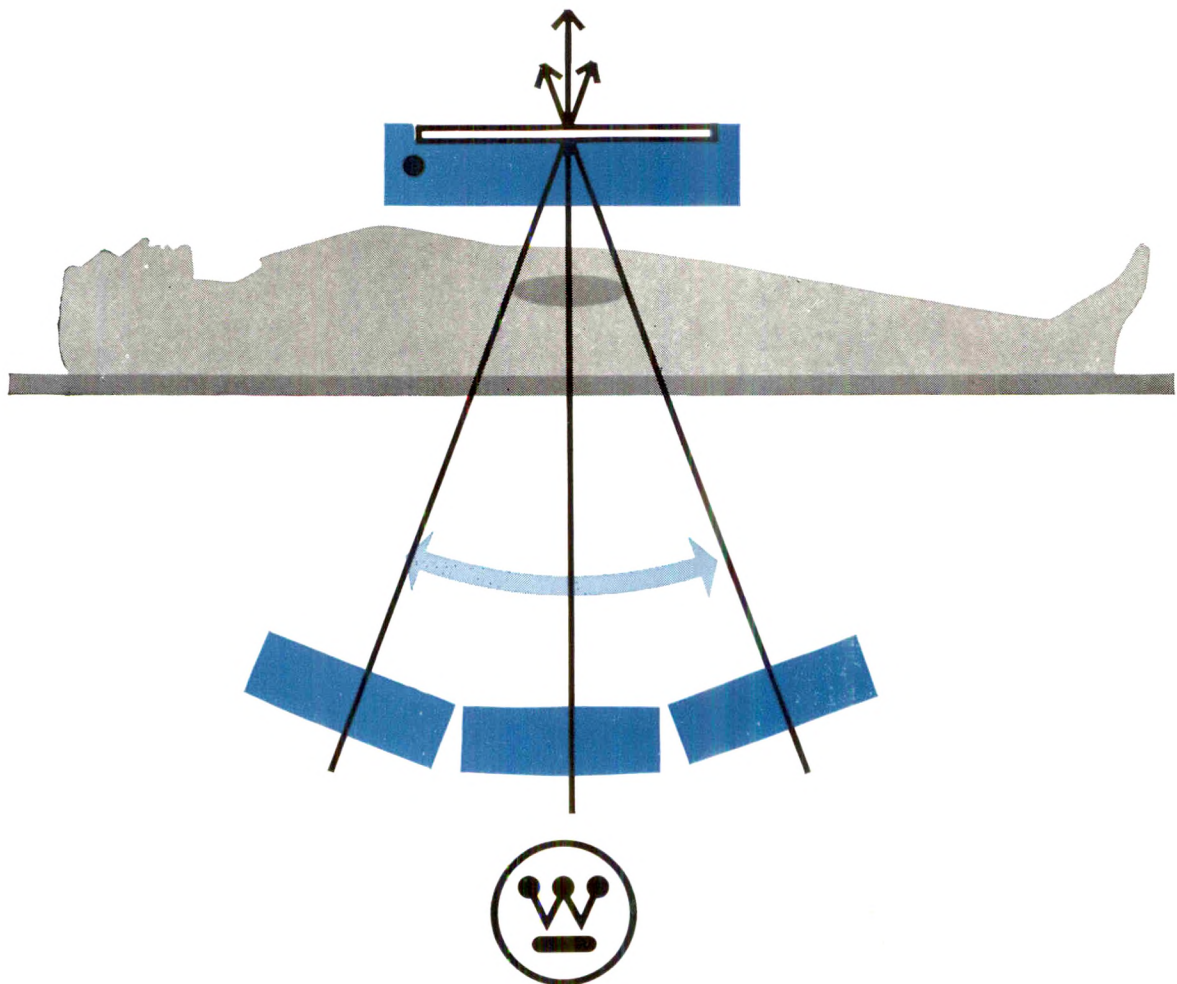
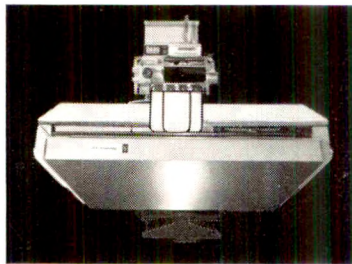
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VOL. 87

MAY, 1962

No. 5

PALATE AND PHARYNX: ROENTGENOGRAPHIC EVALUATION IN THE MANAGEMENT OF CLEFT PALATE AND RELATED DEFORMITIES*

By WILLIAM C. OWSLEY, JR., M.D.
HOUSTON, TEXAS

CONSIDERABLE discussion has appeared in recent years, mostly in the British literature and in some American plastic surgery and speech journals, concerning the value of roentgenologic evaluation as an aid in the management of cleft palate and related pharyngeal malformations. The subject has received little attention in radiological publications of the United States; hence this report.

PURPOSE OF ROENTGENO- GRAPHIC EXAMINATIONS

One of the main problems to be dealt with in treating cleft palate is correction of speech defects; a necessary condition for normal speech is intermittent closure between the nasopharynx and oropharynx during phonation, allowing transient increases in oral breath pressure. Disturbances in this mechanism due to anatomic or physiologic factors produce nasal escape of air and the familiar articulation errors known together as "cleft palate speech."

Pharyngeal closure is effected primarily by upward and backward motion of the soft palate (velum), so that it approximates

the posterior pharyngeal wall; the superior constrictor muscle of the pharynx produces side-to-side narrowing and probably slight forward advancement of the posterior pharyngeal wall in some individuals also, but these factors are relatively minor. Size and shape of the pharynx are of prime importance, since they determine the distance through which the soft palate must move before closure can take place.

Roentgenography can supply much information, difficult to obtain by other means, regarding configuration and function of both the soft palate and pharynx. It has a further advantage over direct or mirror inspection in that it can be done under physiologic conditions, during actual speech. The latter point is particularly important in view of the fact that persons with "cleft palate speech" do not always use their full anatomic capabilities; an anatomic-physiologic correlation may be obtained roentgenographically, with the view toward planning surgery and directing speech training.

The roentgenographic findings are used by the plastic surgeon or speech therapist

* From the Department of Radiology, Hermann Hospital, Houston, Texas.

in several ways: (1) for initial evaluation of the anatomic defects or physiologic deficiencies to be dealt with; (2) to determine whether surgical correction is necessary, and if so, the procedure indicated; (3) to check on operative results; (4) to determine the need for speech therapy or secondary operations; and (5) to determine the amount of physiologic improvement produced by speech therapy and predict the results of additional treatment.

TECHNIQUE

Several techniques have been described,^{1,3,6,7,8,13,14} ranging from single lateral views of the pharynx to sets of 9 or 10 roentgenograms with fluoroscopy, laminagraphy, and contrast media. After some experimentation, we have settled on a basic routine of 3 lateral views of the pharynx, without contrast material.

We have used both a vertical chest stand and a Franklin head unit, but prefer the latter. The patient is seated facing obliquely toward the film holder of the head unit, with his face turned to the side and resting against the unit. The central ray is directed to a point about one inch anterior to and one inch below the external auditory meatus, and a cone is used which will just cover an 8×10 inch cassette. Typical exposure factors for children aged 1 to 3 years are 65 kv., 100 ma. (small focal spot), 0.2 second, 36 inch tube-film distance, standard film with screens and moving grid; for uncooperative subjects we use 200 ma. (large focal spot) and high speed film, cutting the time to 0.05 second. In adults and children over 6 years of age, average factors are 59 kv., 100 ma. (small focal spot), 0.5 second, 36 inch tube-film distance, and standard films with screens and moving grid.

The first film is made at rest, the second with the patient pronouncing the sustained sound "E-E-E," and the third using the syllable "K-A-A." Exposure on the third film is timed to coincide as closely as possible with the "K" portion of the sound.

Many of our patients have been young children; some of them who do not understand the instructions can be coaxed into saying "Mickey Mouse" or some other familiar phrase, and exposure can then be synchronized as well as possible with the "E" and "K" sounds in these words. Useful roentgenograms can sometimes be obtained even in very young or unruly children if roentgenograms are made during crying and in a quiet interval. Crying produces motion of the soft palate comparable to that during speech and will give an indication of the size and pliability of the palate and pharynx, although the degree of motion cannot be relied upon as necessarily representing the true state of affairs to be expected with phonation.

It should be noted that "K" and "E" were chosen more or less arbitrarily as representative consonant and vowel sounds. Persons with palato-pharyngeal incompetence tend to nasalize vowels and to have errors in articulation when pronouncing various consonants. It has been shown that correlation between the degree of incompetence and the amount of speech intelligibility loss is greatest with so-called plosive consonants,¹⁵ which include B, D, G, K, P, and T, so that any of these sounds would probably serve for test purposes. Our reason for using "K" is that its pronunciation is accomplished primarily by motion of the palate and posterior part of the tongue, in contrast to some of the other consonants which require action of the teeth, anterior tongue and lips.

The routine views are sometimes supplemented by additional roentgenograms made while the patient speaks sounds that have been particularly troublesome to him, or as he blows through a small soda straw or whistle. The latter maneuver produces a higher oral breath pressure than ordinary phonation, and can give some indication as to whether observed palatal fixation is due to intrinsic fibrosis or extrinsic factors such as a damaged nerve supply.

Only in rare cases has it been necessary

to use contrast material. We have occasionally had to resort to this method when the palate is distorted or thickened from previous surgery, when there is unusual adenoid hyperplasia destroying the air contrast ordinarily present, or when the patient has choanal atresia, Pierre-Robin syndrome, or other congenital malformations affecting the pharyngeal area. We have found that iodized oil (lipiodol) tends to "make a mess" generally and is not at all satisfactory as a contrast medium in this application. Water-soluble iodized media were also tried, but abandoned because of their bad taste plus some tendency to irritate the nasal mucosa. We now use a thin barium mixture with suspending agent added (micropaque). One or 2 cc. is placed in each nostril with the patient reclining. If he does not sneeze spontaneously he is asked to cough with the mouth closed in order to distribute the barium through the pharyngeal area. A small swallow of the same mixture is then given to coat the tongue, and roentgenograms are made as described above.

Fluoroscopic observation of the palate has been carried out in a number of normal individuals and in persons with cleft palates. This is very interesting to do but we feel that in routine cases it does not furnish enough additional information to warrant the radiation exposure involved. We have not done cineradiography, but feel it would be more useful in speech research than as a routine diagnostic method.

With the knowledge that in routine views we are looking at a curved structure projected on a flat film, we have made a few laminagrams in patients where speech was poor in spite of apparently normal pharyngeal closure, in hopes of finding a source of nasal air escape along the posterolateral aspect of the palate. So far the results have not been promising, a plain submentovertebral projection being more informative.

Determination of lateral dimensions of the pharynx can be easily made in adults or older children using a submentovertebral pro-

jection of the skull. In young children, this view is difficult to obtain, and measurement can probably be better estimated by direct observation through the open mouth.

NORMAL APPEARANCE

At rest, the soft palate lies against the base of the tongue, hanging down in an oblique line or gentle curve from the posterior margin of the hard palate (Fig. 1, *A* and *B*). Normal thickness is 0.5 to 1.0 cm., measured directly from the roentgenograms with no correction for the slight magnification present. While one obviously cannot be dogmatic about measurements of such a mobile structure, figures very far removed from the range above have indicated pathology in our experience. The normal resting soft palate is usually rather uniform in thickness throughout, although it may taper to a sharp margin along the free edge. The lower margin may also terminate in a bulbous shape representing the uvula.

The entire length of the soft palate ranges normally from 2.5 to 4.0 cm., measured from the posterior nasal spine to the free edge. (The posterior nasal spine, representing the most posterior part of the hard palate, is usually not visible on lateral views but its position can be estimated fairly accurately to lie at a level about half way between the pterygoid hamulus and the back edge of the maxillary alveolar ridge, both of which are visible in most cases. This does not hold true in patients with bony clefts in the hard palate, as these individuals usually have no posterior nasal spines.) About 1.0 to 1.5 cm. of soft palate length as measured above represents the uvula plus a free-hanging margin which usually serves no known purpose in speech, although it does tend to close off the oral cavity and direct air through the nose during respiration.

During phonation, the palate moves upward and backward, touching or actually indenting the posterior pharyngeal wall. It usually develops a well-defined angulation of 70 to 100 degrees about the junction of its posterior and middle thirds; this angle

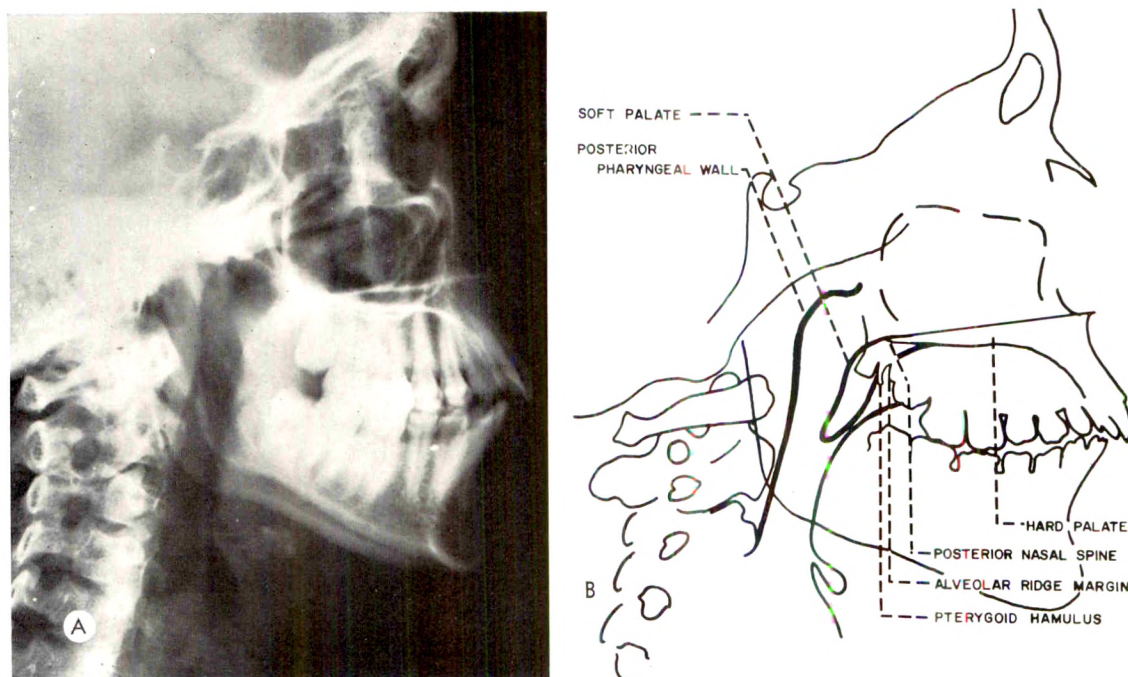


FIG. 1. Normal 19 year old female, during quiet respiration through the nose. Lateral roentgenogram (A) and line drawing (B) of the palate and pharynx, showing the position of these structures at rest.

is produced by the sling-like lifting action of the levator veli palatini muscles and is called the levator eminence (Fig. 2, A and B). It is the apex of this angle which ordinarily touches the pharyngeal wall to produce closure. The point of contact lies slightly above the level of the arch of the atlas in adults, and higher in children. It is important to note this level, since it determines the placement of a corrective pharyngeal soft tissue bar in some surgical repair procedures.

The anterior portion of the palate usually thins slightly during phonation, although the reverse may sometimes occur; the posterior portion may thicken, or flatten itself against the pharyngeal wall. Over-all length does not change markedly. With normal neuromuscular activity and normal closure, the soft palate rises in line with or slightly above the level of the hard palate during speech, provided its motion is not obstructed by impingement on hypertrophic adenoid tissue. Additional elevation is produced by blowing against the resistance of a soda straw or whistle.

In studying the pharynx, its depth,

width, and shape are the factors to be considered. We have not found any meaningful way to measure depth or shape because no consistent reference points are present which correlate directly with the clinical problems encountered. A subjective evaluation seems best, taking into account the relative length and position of the soft palate, angle and height of the hard palate, degree of inclination of the posterior pharyngeal wall, and thickness of the posterior pharyngeal soft tissues. In this way, a fairly good estimate can be made of the size of the opening which must be blocked by the soft palate to close the nasopharynx.

Pharyngeal width as measured on the submentovertex projection averages about 4.5 cm. with a range of 3.5 to 6.5 cm. (Fig. 3, A and B). Up to 1.5 cm. lateral narrowing takes place during phonation although the amount is usually less than this.

The presence and size of adenoid tissue should be noted, as this tissue sometimes makes the difference between air leakage and competent closure, and its removal in such cases would be a serious mistake (Fig. 4, A and B). At times, in some patients, a

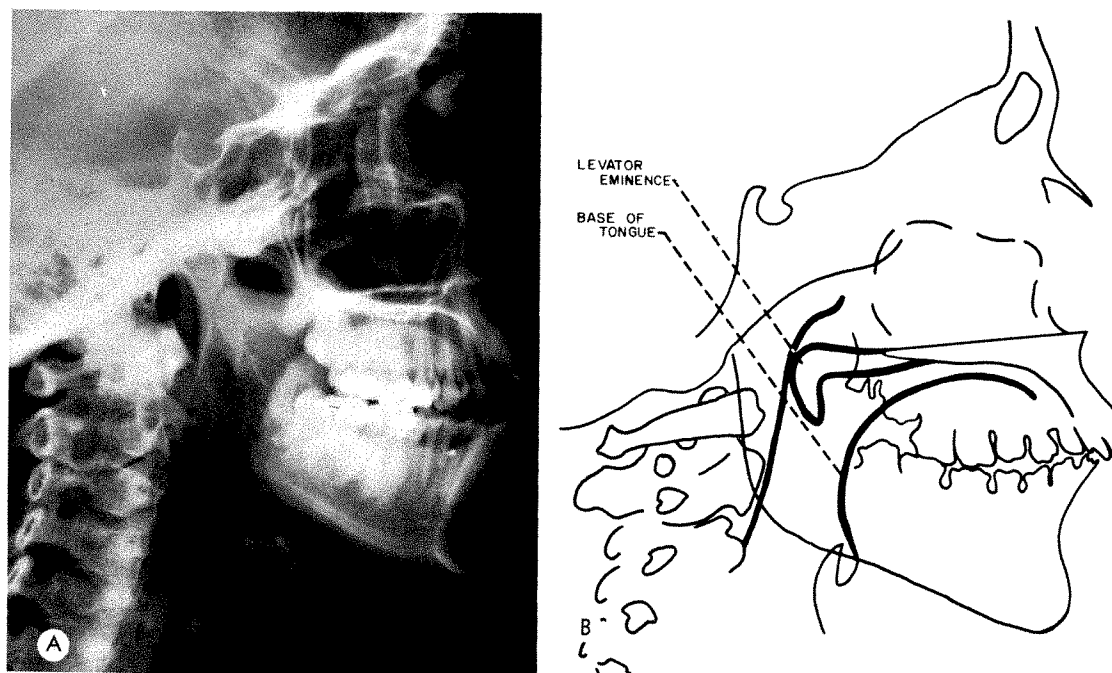


FIG. 2. Same patient as in Figure 1, saying "E-E-E." Roentgenogram (A) and line drawing (B). Note the change in relationship between the soft palate, posterior pharyngeal wall, and tongue, as compared with the resting position. The levator eminence contacts the pharyngeal wall to close the pharyngeal isthmus.

localized muscular protrusion develops on the lower posterior pharyngeal wall during phonation. This is known as Passavant's ridge,^{2,12} and has been supposed by some authors to take part in a pharyngeal sphincter mechanism. We do not feel that this is true in the normal individual because (1) the ridge is seldom seen in normal subjects and (2) when present in our control cases it was always located too low to play any significant role in closure. It does unquestionably act as a secondary aid in an occasional patient with an abnormal palate and an unusually high or well-developed Passavant's ridge (Fig. 5).

Motion of the tongue and position of the anterior teeth, although not directly related to pharyngeal closure, are important in normal speech. We, therefore, note the degree of anterior motion of the base of the tongue during phonation, and look for evidence of gross dental occlusion errors.

PATHOLOGIC FINDINGS

When a large, unrepaired, palatal cleft is present, the two halves of the palate re-

tract laterally against the fauces and cause a hazy or unrecognizable shadow so that it appears on roentgenograms as though the soft palate were missing (Fig. 6). After repair of the cleft, the palate may have a normal appearance or may show varying degrees of shortening (Fig. 7). It may be thicker or thinner than normal (Fig. 8), and instead of a uniform thickness may show localized bulges or narrow spots, and more than the usual degree of tapering toward the free edge. Motion may be restricted, or ineffectual in type (Fig. 9); this can be due to fibrosis, damaged nerve supply, submucous muscular defects, or lack of neuromuscular training. If some elevation can be produced by blowing on a straw or whistle, a cause of restricted motion other than fibrosis is suggested. If the palate is too short or moves insufficiently to contact the pharyngeal wall, measurement of the residual gap should be made for future reference. Articulation errors and noticeable nasal air escape may begin to appear when the gap reaches 1.5 to 2 mm. in size, and usually

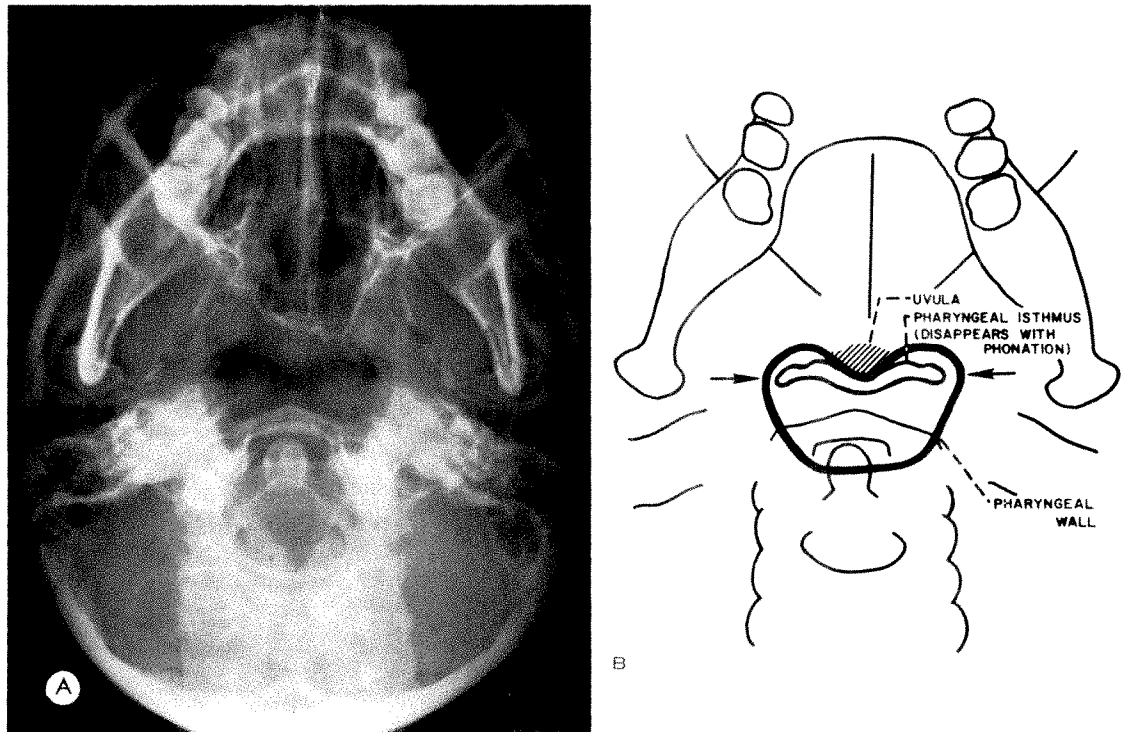


FIG. 3. Normal 32 year old female. Submentovertex roentgenogram of the skull (A) and corresponding line drawing (B) showing the outline of the pharynx. Width is measured between the arrows. The pharyngeal isthmus is the gap between the soft palate and posterior pharyngeal wall. In the normal individual, it disappears with phonation.

become severe as it increases beyond 5 mm. or so.

If the soft palate seems to have a normal length and moves well, but still fails to

contact the pharyngeal wall, the cause of the difficulty can then be referred to as "congenital deep pharynx" (Fig. 10). Since the pharyngeal wall slopes downward and

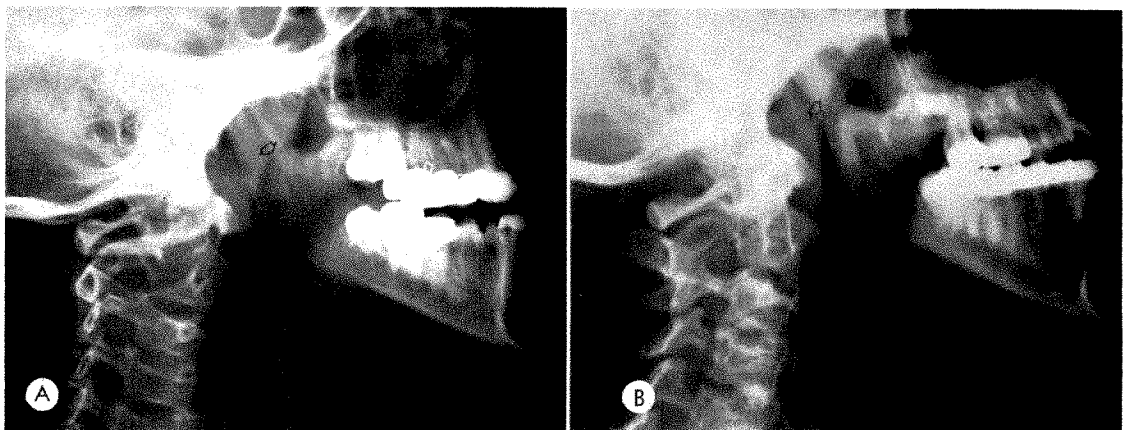


FIG. 4. (A) Eleven year old girl, saying "E-E-E." Primary cleft palate repair at 2 years of age; secondary repair and push-back operation at age 10. The soft palate is a little short, but contacts a large adenoid pad and closes the nasopharynx satisfactorily (arrow). Normal speech. (B) Same patient 3 years later. Tonsils and adenoids were removed in the interval. There is now a gap of 6 mm. between the levator eminence and the pharyngeal wall (arrow). Articulation errors and nasal air escape are present.

backward, closure difficulties can also be produced by low position of the hard palate or increased backward slope of the pharynx. The opposite situation exists in Pierre-Robin syndrome, where the hard palate is quite high and may contact the pharyngeal wall at rest, obstructing the nasal airway (Fig. 11). Another condition we have noted in a few patients is excessive slope of the hard palate, so that it lies almost parallel to the pharyngeal wall and remains quite a distance away from it.

Normal development of the levator eminence is absent after surgical repair if excess fibrosis has developed, and in these cases the entire soft palate simply swings backward on phonation as though it were a stiff structure attached to the hard palate by a hinge. Also, the location of the levator eminence may be too far forward so that much of the back part of the palate hangs down like a curtain and fails to serve any effective purpose (Fig. 8). In one of our



FIG. 6. Unrepai red palatal cleft in a 12 year old girl, during phonation. The soft palate is retracted against the fauces, and appears to be missing.

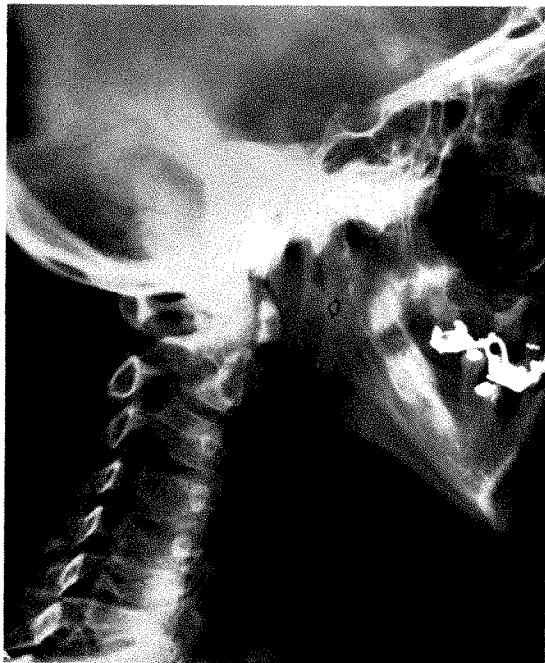


FIG. 5. Medium sized Passavant's ridge (arrow), somewhat higher than the usual location. White female, aged 33, saying "E-E-E." This patient has had several operations on the palate and prolonged speech therapy.



FIG. 7. Seventeen year old boy showing short palate, following primary repair of a cleft at age 5. Closure defect of 8 mm. (arrows), with severe speech handicap. The patient subsequently had a push-back operation and speech therapy, with excellent results.

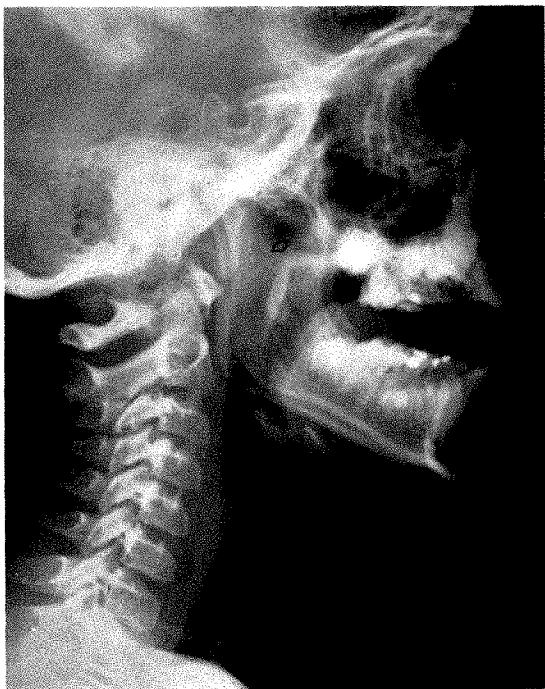


FIG. 8. Submucous cleft in an 8 year old girl with nasal speech. Roentgenogram made during pronunciation of the syllable "K-A-A." Although the palate is of normal length, closure does not take place, as the levator eminence (arrow) is located too far forward. Palatal thickness is only 3 mm.



FIG. 10. "Congenital deep pharynx" in a 5 year old boy. The soft palate is normal in length and shows good motion, but cannot reach the back of the very deep pharynx. Gap of 1.1 cm. is visualized when patient is saying "K-A-A." The cranial base is almost horizontal.

cases, the levator eminence formed normally, but moved straight up instead of upward and backward, so that contact did not take place.

FINDINGS AFTER SURGICAL PROCEDURES

Surgical corrective procedures (aside from simple cleft repairs) fall into several main categories according to purpose:

1. Procedures designed to produce retro-position and/or increased mobility of the soft palate, generally referred to as push-back operations. The common feature is lengthening of the soft palate by tissue



FIG. 9. Ineffectual motion of the palate with defective speech in a 5 year old boy, who had a cleft palate repair and push-back operation when 2 years of age. At rest, the palate has a normal appearance; on phonation (above) it becomes shorter and thicker, suggesting contraction of the tensor veli palatini with inactive levator muscles. It fails to contact the pharyngeal wall by a distance of 6 mm., although its length is normal. Benefit would be expected from speech therapy in a case such as this.

obtained from the surface of the hard palate or pharyngeal region (Fig. 12). Most of these operations are done as primary procedures, along with repair of palatal clefts, although they may also be used as secondary operations if initial surgery has not been completely successful. Examples are the Dorrance⁹ push-back, and the Wardill¹⁶ and Kilner¹⁰ V-Y operations; modifications of the latter are called three-flap or four-flap operations.

2. Procedures which move the posterior pharyngeal wall anteriorly or place a soft tissue bar opposite the palate to facilitate closure. Some of these operations also produce side-to-side narrowing of the pharynx. They are generally referred to as pharyngoplasties, and are accomplished by using pharyngeal wall flaps or by placing



FIG. 11. Pierre-Robin syndrome in a 6 day old infant. Note the high position of the hard palate and scanty nasal airway. The base of the tongue rests against the base of the posterior pharyngeal wall, also obstructing respiration.

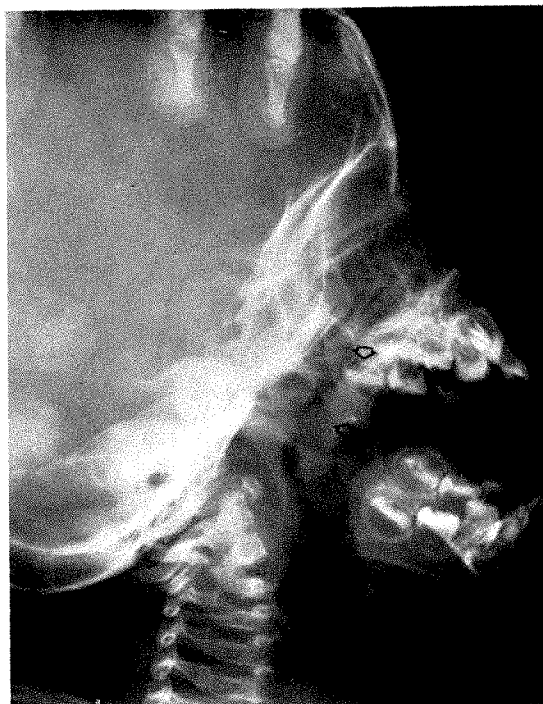


FIG. 12. Push-back operation, as modified by Cronin. Thirteen month old girl. The distance between the wire suture markers (arrows) shows the amount of palatal retroposition obtained at surgery (1.4 cm. in this case). Any decrease in this distance on follow-up roentgenograms will give an indication of scar tissue contraction.

implants of cartilage or plastic material beneath the pharyngeal mucosa (Fig. 13, *A* and *B*). Examples are the Hynes⁹ and Moore¹¹ pharyngoplasties.

3. Combined procedures. An example is the "posterior pharyngeal flap" operation (Rosenthal), in which a superiorly or inferiorly based posterior pharyngeal flap is left attached to the soft palate, pulling it backward mechanically, and narrowing the pharynx at the same time (Fig. 14). This is one of the commonly used secondary operations for correction of palatopharyngeal incompetence.

The hoped-for changes in roentgenographic appearance after surgery can be deduced from the type of operation done, so it is not necessary to dwell on post-operative findings, but a few remarks may be in order. Roentgenographic follow-up examination should be delayed at least a

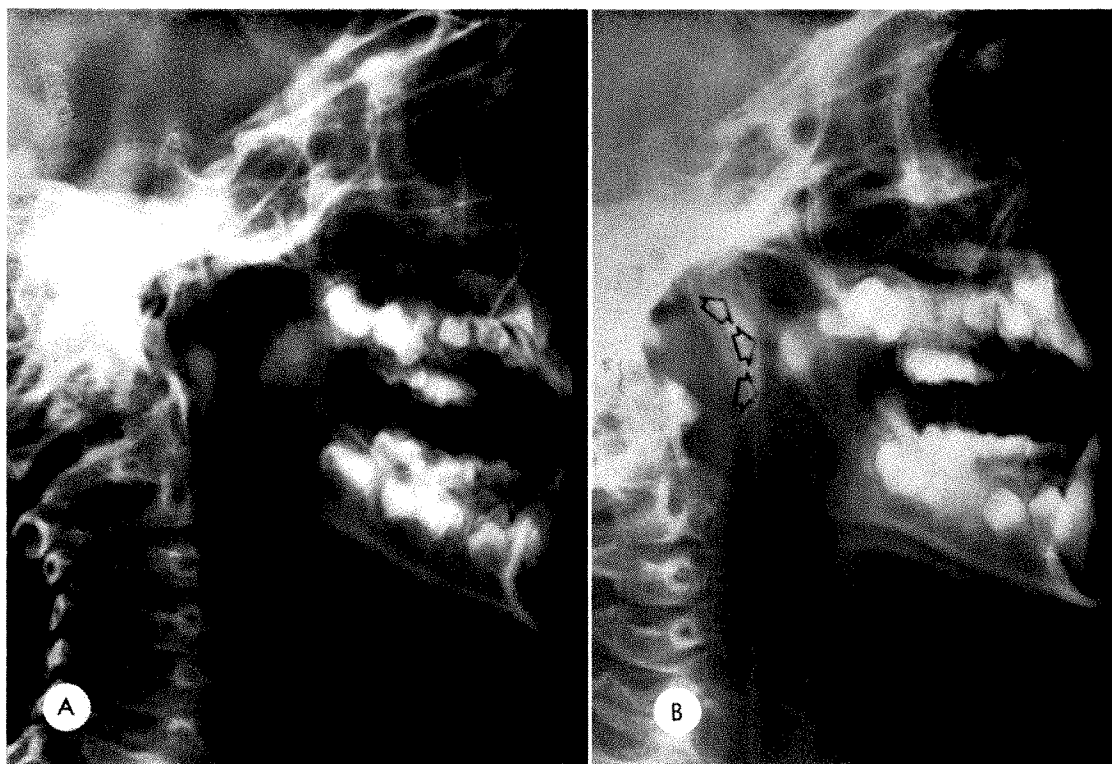


FIG. 13. (A) Girl, aged 10. Had first and second stage cleft palate repairs at age 3. Rather short soft palate with incompetence (8 mm. gap) and severe speech defects. (B) Same patient after cartilage implant pharyngoplasty. Note the bulge in the pharyngeal soft tissues (arrows) overlying the implant, reducing the air gap to 2 mm. Speech much improved.



week or two after operation to prevent confusion with postoperative edema; a longer interval is desirable in order to allow palatal motion and flexibility to reach maxima. Roentgenographically, it is not possible or necessary to distinguish the type of operation done, except between the 3 general groups above; it is sufficient to determine the amount of lengthening of the palate or shift in the pharyngeal wall and to assess the size of the residual gap be-

FIG. 14. Posterior pharyngeal flap operation (Rosenthal type). The flap can be seen between the arrows, connecting the soft palate to the posterior pharyngeal wall in the midline. Gaps are present laterally on each side (not visible in this view), which allow passage of air into the nasopharynx in the resting position. During phonation, these gaps close in the same way as a normal pharyngeal isthmus.

tween the two structures, if any. A change of the order of 1 cm. from preoperative findings would be considered a good result; gaps of up to 3 cm. or even more can sometimes be closed by operation on both the palate and pharynx.

One of the problems in push-back operations has been loss of some of the palatal lengthening obtained at surgery, due to postoperative scar tissue contraction on the raw nasal surface of the palate. Cronin⁴ has originated a surgical technique designed to prevent this, and has placed wire suture markers in the palate to allow contraction to be measured on postoperative roentgenograms (Fig. 12). Preliminary studies indicate that little or no palatal shortening occurs with his procedure.

When a patient is undergoing speech therapy, repeated examinations at intervals of several months are very helpful in determining development of muscular control. We have seen several cases in which normal speech has been obtained under therapy, accompanied by a change in roentgenographic findings from apparent paralysis of the palate and pharynx to normal motor activity.

SUMMARY

During the past six years, we have used roentgenography as an adjunct to clinical evaluation of the palate and pharyngeal region in cleft palate and related deformities. The method is described and normal findings outlined, along with some brief information on speech physiology, abnormal findings, and surgical corrective procedures.

The examination is a simple one which requires no special equipment or techniques, and it can be very helpful in the diagnosis and management of cleft palate abnormalities. It is recommended in such cases, especially when surgery is contemplated or speech therapy is in progress.

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I should like to express my thanks to Drs. Thomas D. Cronin and Raymond O. Brauer,

who referred most of the patients included in this study, and supplied information on surgical repair procedures and clinical progress.

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CONTRAST LARYNGOGRAPHY IN THE EVALUATION OF LARYNGEAL NEOPLASMS*

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THE otolaryngologist establishes the nature and extent of a laryngeal lesion by indirect and direct laryngoscopy and by biopsy of suspicious areas. Certain situations exist, however, which make accurate clinical classification of a lesion difficult, as in the case of bulky supraglottic and subglottic tumors which obscure adequate visualization of adjacent structures. Roentgenograms of the neck and frontal laminagrams aid in describing normal and abnormal soft tissue densities, but these studies have the disadvantage of demonstrating poorly certain regions which are not situated in the sagittal or coronal planes, as for example, tumors of the false vocal cords and laryngeal ventricles.

Contrast laryngography may prove of great value as an adjunctive diagnostic procedure for the evaluation of laryngeal cancers, and thereby aid the otolaryngologist and radiotherapist properly in evaluating each patient for therapy. It is expected that the use of contrast material to demonstrate the pathologic anatomy of the larynx and hypopharynx by means of techniques of image intensification fluoroscopy will permit the radiologist (1) to accurately describe the position of neoplasms in the intrinsic and extrinsic larynx, (2) to determine the limits of the tumor mass and possible extent of spread to surrounding structures, and (3) to evaluate impaired function of the pharynx and laryngo-esophageal complex.

HISTORY

Although the earliest roentgenologic studies of the neck have been attributed to Scheier³⁰ in 1896, it was not until 1922

that Coutard⁸ developed the technique of roentgenographic examination of the hypopharynx and larynx by means of lateral soft tissue roentgenograms of the neck. This method has remained the fundamental technique for the evaluation of lesions arising in the larynx,^{10,14,15,19,20,25,32} and its value in the diagnosis and treatment of head and neck tumors has been described well by Baclesse,^{2,3} Coutard and Baclesse,⁹ Pendergrass and Young,²⁸ Fletcher and co-workers,^{12,13} and others.^{16,22,26,27,31} The development of laminagraphy permitted the examination of the soft tissues in the frontal plane^{6,7,23,33} and recently, Brauer⁵ utilized laminagraphic studies of the larynx following the introduction of radiopaque media, thereby obtaining further information in the roentgen diagnosis of tumors arising in the neck.

Radiopaque visualization of the tracheo-bronchial tree was devised by Jackson,¹⁸ who in 1918 reported the use of intrabronchial insufflation of bismuth subcarbonate through a bronchoscope for the localization of foreign bodies. Iglaue¹⁷ injected iodized oil to examine the larynx, trachea, and bronchial tree, but this method was not further developed until 1936, when Jackson¹⁹ utilized lipiodol for the contrast examination of the larynx and pharynx. With the synthesis of more satisfactory radiopaque media for uniform mucosal coating, various methods of contrast laryngography were reported by Ardran *et al.*,¹ Baclesse,³ Borden and Berger,⁴ Fariñas,¹¹ Huët and Peri,¹⁶ Lecco *et al.*,²⁴ Lindgren,²⁵ Kelemen,²¹ Mathey-Cornat,²⁶ and Worning.³¹ Powers *et al.*²⁹ reported in the American literature a simple and reliable surface

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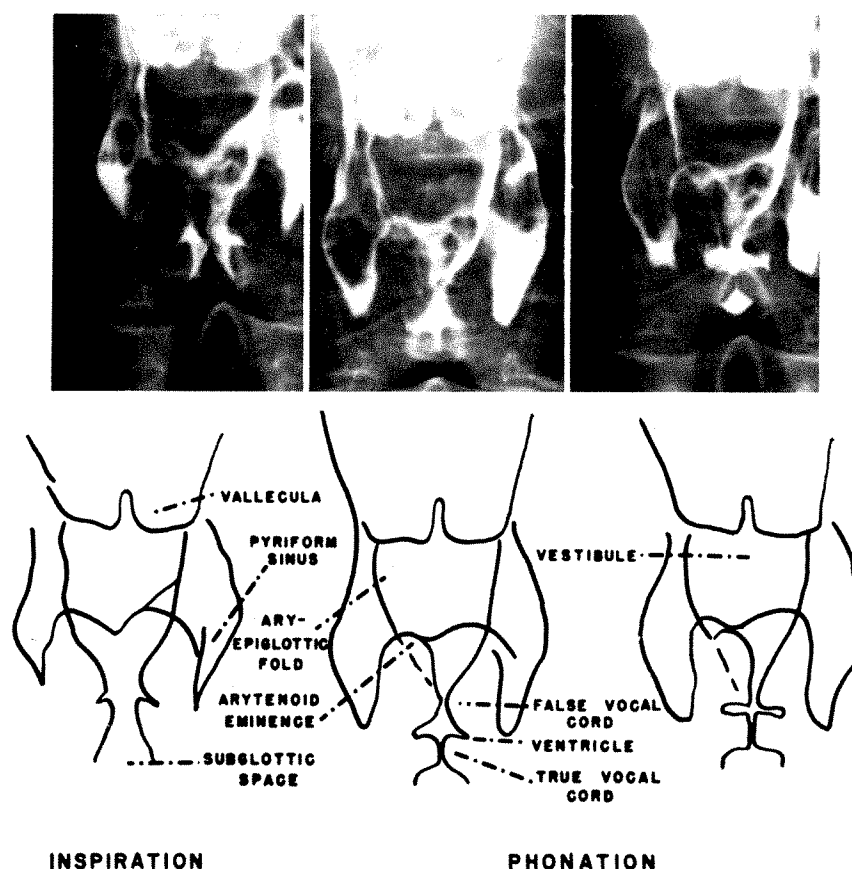


FIG. 1. Case 1. Lesion of the left true vocal cord.

contrast technique for the roentgen examination of the larynx and pharynx utilizing dionosil oily. A modification of this technique has been the method applied and developed at The Johns Hopkins Hospital and made possible by the introduction of television image intensification fluoroscopy and simultaneous cinefluorography.

MATERIALS AND METHODS

Patients admitted to The Johns Hopkins Hospital with suspected tumors of the larynx are referred from the Division of Otolaryngology to the Department of Radiology for diagnostic evaluation. The radiologic examination is divided into three stages; namely, (1) anteroposterior and lateral soft tissue roentgenographic and fluoroscopic studies of the neck, (2) frontal laminagraphy of the larynx, and (3) roentgenographic and fluoroscopic studies of the

hypopharynx and esophagus using barium sulfate or other opaque media. During the past year, a contrast medium examination of the larynx and hypopharynx has become an integral study in the evaluation of these patients.

TECHNIQUE

Emphasis is placed on proper anesthesia of the larynx since this is necessary for the introduction of adequate contrast material and satisfactory mucosal coating. Pre-medication consists of 0.4 mg. atropine sulfate subcutaneously, and 100 mg. of seconal administered one hour before the examination.

Topical anesthesia (0.5 per cent pontocaine) is sprayed into the oropharynx, hypopharynx, over the epiglottis, and finally into the larynx. A curved metal applicator with a cotton tip soaked in

pontocaine is introduced into each pyriform sinus and held there for one minute. When the patient no longer reacts to instrumentation, he is usually adequately anesthetized.

The patient is positioned at the fluoroscopic screen and is instructed not to cough, swallow, or talk during the examination. The radiologist explains the procedure of quiet inspiration, phonation of "ee," the modified Valsalva maneuver, and the true Valsalva maneuver, and executes a trial run with the patient for each procedure.

While the patient breathes quietly, a curved metal cannula is introduced into the oropharynx and 6 to 10 cc. of aqueous dionosil is dripped over the back of the tongue and distributed equally into the pyriform sinuses, the vallecula, and over the epiglottis. The examination is conducted with television image intensification

fluoroscopy and remote cinefluorography, utilizing high kilovoltage technique and rapid exposure or phototiming. Fluoroscopic spot roentgenograms are taken intermittently with cinefluorographic studies.

ILLUSTRATIVE CASES

CASE I. (Fig. 1.) These laryngograms demonstrate the radiologic anatomy of the larynx and hypopharynx in the anteroposterior projection. The patient, a seventy year old male, complained of hoarseness for a period of four years. On direct laryngoscopy, a hyperkeratotic lesion which extended the length of the left true vocal cord was observed, with no evidence of involvement of the anterior commissure. The false cord and arytenoid mass were reddened and edematous. Complete mobility of the true cord was evident. The laryngograms demonstrated only some swelling in the region of the left vestibular wall with broadening and elevation of the ary-

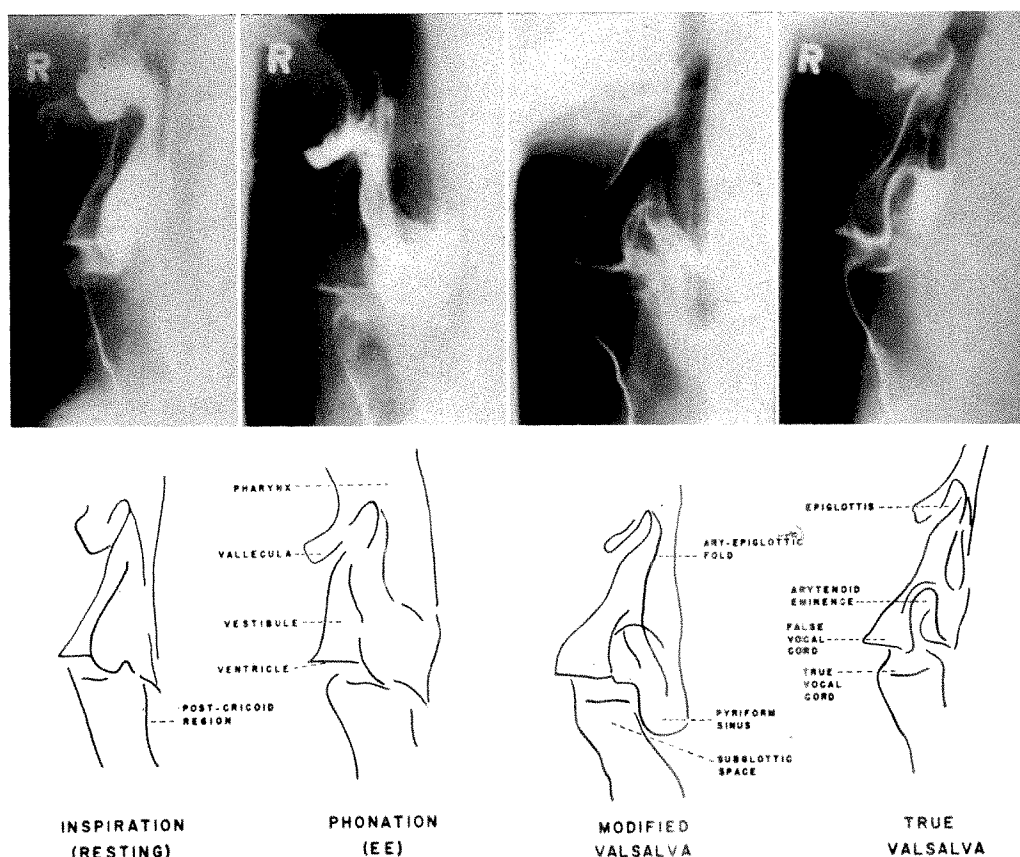


FIG. 2. Case II. Normal laryngograms, lateral study.

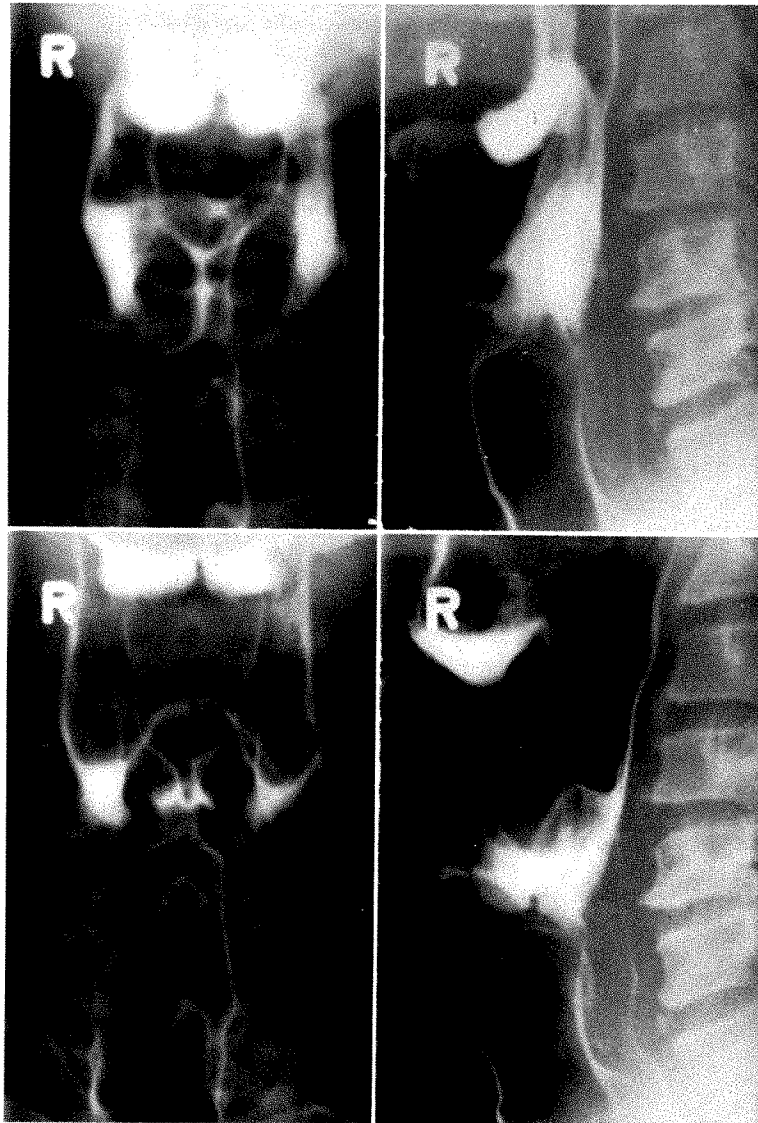


FIG. 3. Case III. Right vocal cord paralysis due to involvement of the right recurrent laryngeal nerve.

tenoid mass and sluggishness of the left false cord.

CASE II. (Fig. 2.) In these lateral laryngographic studies, quiet inspiration, phonation of "ee," the modified Valsalva maneuver, and the true Valsalva maneuver are depicted. The laryngeal triangle, *i.e.*, the laryngeal surface of the epiglottis, the laryngeal ventricle, and the aryepiglottic folds, is readily identified in this projection. During phonation the epiglottis stands erect and the pharynx is widened. The cords are best seen during phonation and the Valsalva maneuver as are the pyriform sinuses.

The anterior commissure can be evaluated only on this projection.

CASE III. (Fig. 3.) This sixty-four year old male complained of shortness of breath and of two occasions of hemoptysis three weeks prior to admission. An acute pneumonia was demonstrated in the left upper lobe which responded satisfactorily to antibiotic therapy and conservative measures. Bronchoscopy was negative, and a bronchogram failed to reveal evidence of significant disease. At the conclusion of bronchography, laryngography was done in order to obtain a normal study. It was immedi-

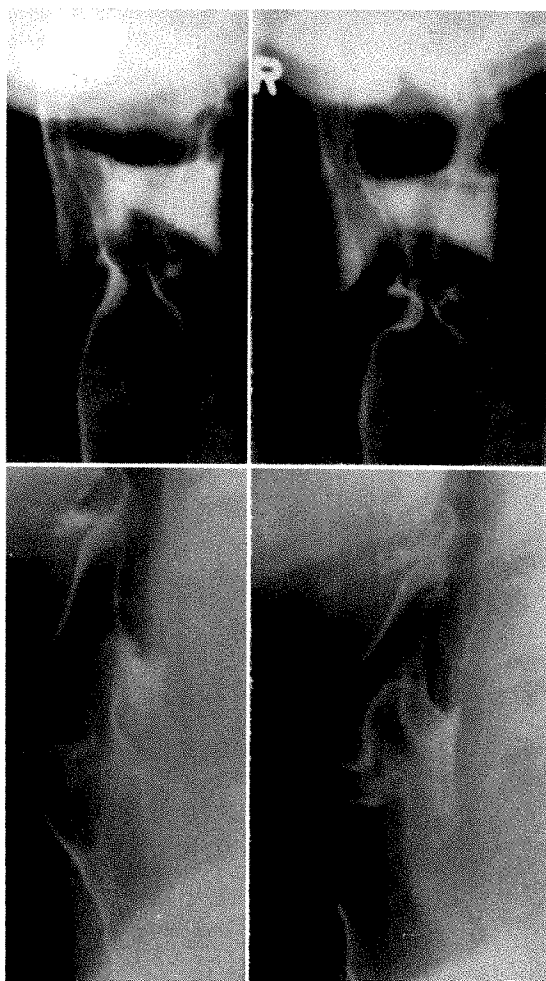


FIG. 4. Case IV. Left recurrent laryngeal nerve paralysis due to extension of bronchogenic carcinoma.

ately noted that the right true vocal cord failed to retract on inspiration, and that the right false cord was quite sluggish. On phonation, the right true cord came to the midline, was somewhat thickened, and the laryngeal ventricle was larger than on the normal side. The appearance was that of vocal cord paralysis due to involvement of the right recurrent laryngeal nerve.

On further inquiry, the patient stated that he had had a husky voice for a number of months. He is presently being evaluated for a probable bronchogenic neoplasm.

CASE IV. (Fig. 4.) This fifty-two year old male lost his voice abruptly in June, 1960, which he attributed to laryngitis since he felt quite well otherwise. His voice returned within

a day, but he subsequently became inaudible for periods of one hour until September, 1960. At that time he could only whisper, and a roentgenogram revealed a large mass lesion in the left chest. On laryngoscopy, complete paralysis of the left true vocal cord was observed. Subsequent biopsies confirmed the diagnosis of bronchogenic carcinoma.

Laryngograms demonstrated the classic appearance of left recurrent laryngeal nerve paralysis. Fixation of the left cord was noted at all times, and there was evidence of abduction of the unaffected true cord during inspiration. During phonation, the paralyzed cord did not alter its position, while the normal cord was rounded and approximated the midline. Because of the projecting shelf formed by the fixed cord, the subglottic mucosal surface on the affected side was not as readily coated as on the normal side.

CASE V. (Fig. 5.) This fifty-nine year old male had a history of sore throat for six months and hoarseness for a period of three weeks prior to admission. On examination he had audible stridor and evidence of swelling on the right side of the neck. On laryngoscopy, the epiglottis was found to be twisted to the right, the pyriform sinuses could not be satisfactorily seen, and the glottis was obscured by a large, polypoid, ragged growth. The lesion arose in the region of the left false cord, extended across the anterior commissure, and involved the right false cord as well. Along the right ventricular fold a large polypoid growth was present. The left false cord and arytenoid were fixed, while only minimal mobility was noticed on the right.

Laryngograms demonstrated the neoplasm to involve the entire vestibule, and to extend the length of the laryngeal surface of the epiglottis, as well as of the aryepiglottic folds. The pyriform sinuses were compressed and distorted by the pressure of the mass, and motion during inspiration was confined only to the right side. The subglottic arch was symmetrically narrowed in the anteroposterior projection, but otherwise appeared free of invasive carcinoma.

CASE VI. (Fig. 6.) This seventy year old male complained of hoarseness with some vague pain around the throat for a period of eight weeks. On direct laryngoscopy the larynx appeared markedly reddened and edematous, with particular swelling of the right false cord. Irregu-

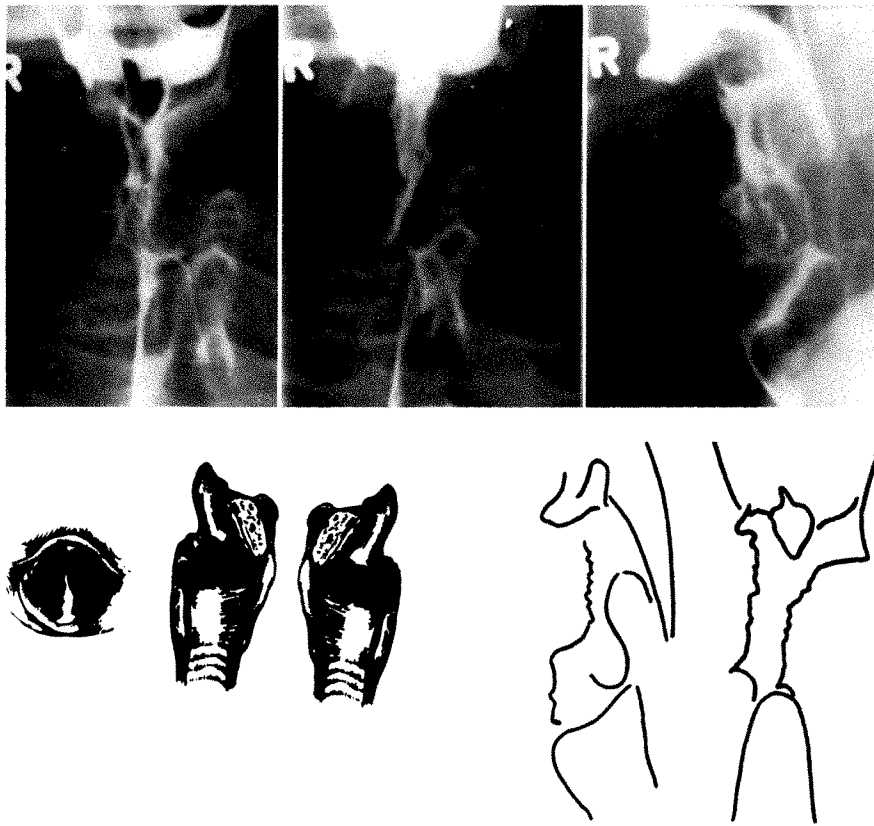


FIG. 5. Case v. Carcinoma of the supraglottic region of the larynx.

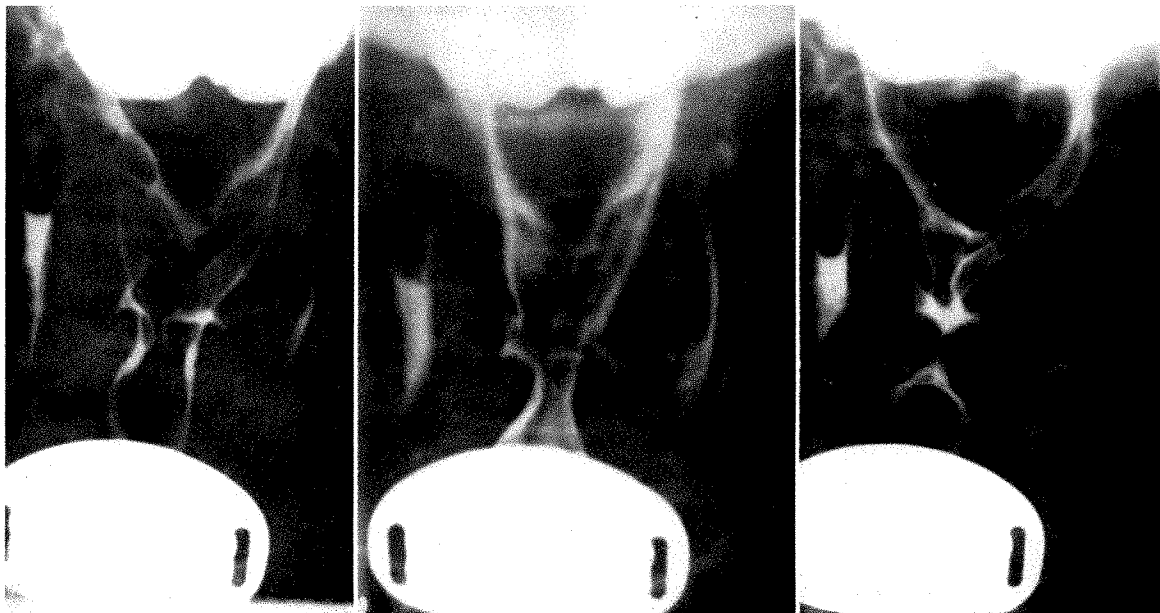


FIG. 6. Case VI. Carcinoma of the right laryngeal ventricle.

larity was noted in the region of the right ventricle from which herniated a hard tumor mass. This apparently encroached upon the thickened ventricular fold above, but did not extend beyond the ventricle to the true vocal cord, although fixation of the true cord was apparent. Biopsy revealed squamous cell carcinoma arising in the right laryngeal ventricle.

Laryngograms demonstrated a thickened false cord on the right, an irregular double contour in the region of the right ventricle, and swelling of the arytenoid mass on the same side. The medial border of the adjacent pyriform sinus was flattened and irregular, presumably due to extrinsic pressure by the mass. The laryngeal ventricle was fixed and tilted superiorly, during both attempted phonation and Valsalva maneuvers.

Roentgen therapy was begun in September, 1960, and a tumor dose of 6,000 r was delivered in six weeks. Laryngograms were obtained three months following the completion of therapy. These demonstrated mobility of both the true and the false vocal cords, only minimal asymmetry of the ventricular walls and aryepiglottic folds, and complete disappearance of a distorting mass. Only minimal fixation of the affected laryngeal ventricle was noted. On direct laryngoscopy, no evidence of tumor was present.

CASE VII. (Fig. 7.) This twenty-one year old Coast Guard seaman had been hoarse since the age of thirteen. It was always assumed by the patient, his family, and his physician that the youth had a naturally husky voice. He had no history of laryngitis, polyps, or discomfort as-

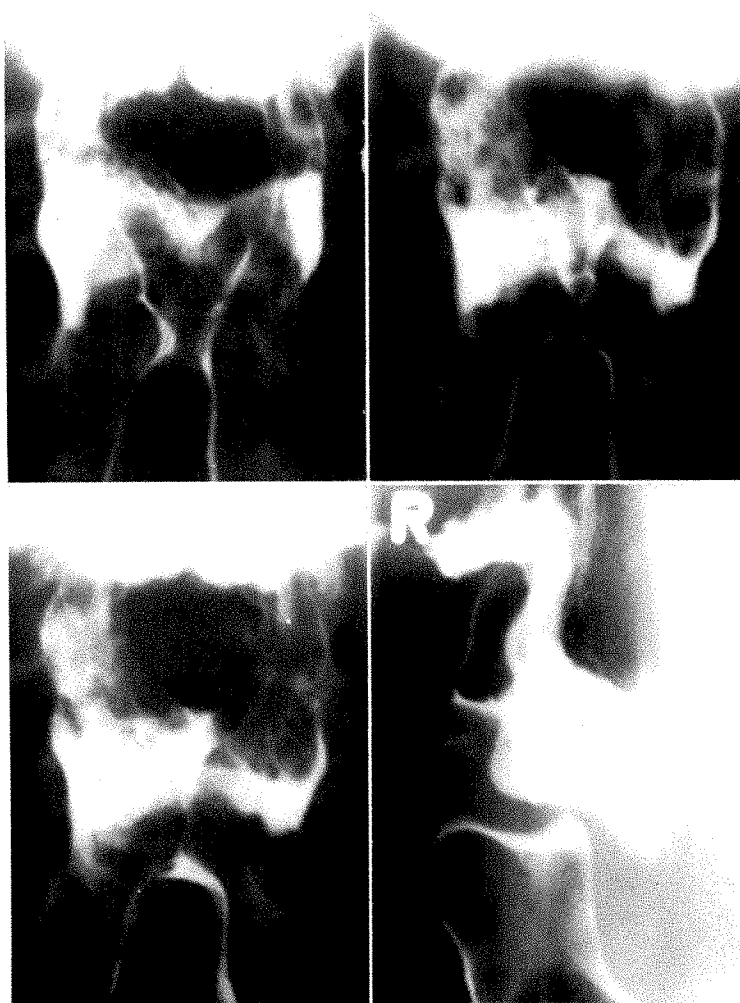


FIG. 7. Case VII. Carcinoma of the glottic region of the larynx.

sociated with this hoarseness. Six months previously he was unable to speak without conscious effort to force his voice. Examination at that time revealed a hyperkeratotic lesion extending over the anterior two-thirds of both vocal cords and involving the anterior commissure. Multiple biopsies revealed squamous cell carcinoma limited to the surface of the cords, with only one area of questionable invasion.

On laryngograms, only minimal irregularity of the true vocal cords was noted. However, partial loss of mobility was demonstrated by the inability to abduct completely the cords, particularly on the right, during inspiration. On phonation, the true cords were thickened, and did not approximate satisfactorily in the midline. The laryngeal ventricles were partially obliterated. During the Valsalva maneuver, the subglottic area appeared normal. On the lateral projection, the true vocal cords were moderately thickened.

CASE VIII. (Fig. 8.) This sixty-two year old male noted the onset of sore throat and hoarseness in September, 1960. On direct laryngoscopy a hyperkeratotic lesion was identified on the left true vocal cord with chronic inflammation which involved both false cords. Multiple biopsies during the next four months finally confirmed the diagnosis of Grade II squamous cell carcinoma.

Laryngograms performed just prior to radiation therapy revealed partial fixation of the left true vocal cord, irregularity of the surface of the laryngeal ventricle and of the left false cord. There was shortening and blunting of the inferior angle of the left pyriform sinus. Evidence of sluggishness of the true and false cords on the affected side was present on phonation (Fig. 8, upper).

After three weeks of radiation therapy, fixation of the affected side was less apparent. Mobility of the cords on inspiration and phonation was much improved and the angles of the pyriform sinuses were more symmetric (Fig. 8, lower).

CASE IX. (Fig. 9.) This sixty-one year old male underwent a course of radiation therapy in 1957 for carcinoma of the right vocal cord. In June, 1959, a recurrent lesion was demonstrated, involving the right vocal cord with complete fixation. Laryngograms demonstrated immobility of the right true and false cords,

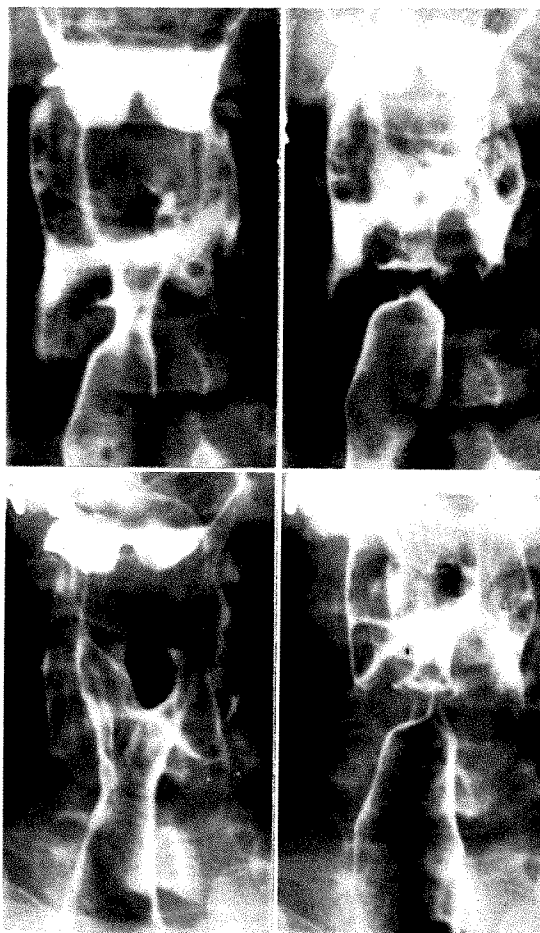


Fig. 8. Case VIII. Carcinoma of the left true vocal cord prior to radiation therapy (upper) and after three weeks of radiation therapy (lower).

fixation of the laryngeal ventricle, and a mass which extended submucosally and distorted the subglottic area and the adjacent hypopharyngeal structures (Fig. 9, upper).

A total laryngectomy was performed and revealed undifferentiated squamous cell carcinoma. At operation, the epiglottis and hyoid bone were preserved.

Six months later, the patient complained of progressive dysphagia with pain in the upper cervical region. Barium studies of the hypopharynx revealed a prevertebral mass distorting and invading the upper esophagus, and which proved to be a post-cricoid recurrence of the tumor (Fig. 9, lower right).

CASE X. (Fig. 10.) This sixty-seven year old male had a history of progressive hoarseness of one year's duration. Five weeks prior to admis-

sion, an emergency tracheostomy was performed by his family physician, following which the patient's dyspnea immediately improved.

On laryngoscopy, fixation of the left vocal cord and poor mobility of the right vocal cord were noted. A fungating irregular mass which covered the internal surfaces of the cricoid region was identified posteriorly and on both sides, but the extent of anterior involvement could not be determined.

Laryngograms readily demonstrated the position of the lesion, the involvement of adjacent structures, the distal extent of the subglottic extension, particularly along its anterior margin, and the paratracheal location of the tracheostomy tube in the soft tissues of the neck.

The patient underwent a total laryngectomy and bilateral radical neck dissection for carcinoma of the larynx. Extensive metastatic dis-

ease was found involving the lymph nodes of the mediastinum.

CASE XI. (Fig. 11.) This sixty-two year old female noted the progressive onset of stridorous breathing three months prior to admission. Direct and indirect laryngoscopy revealed the left vocal cord to be almost completely fixed in the paramedian position. There was a subglottic tumor on the left which was smooth and obstructed 75 per cent of the airway.

Laryngograms demonstrated a large, smooth, subglottic mass lying to the left and posteriorly between the posterior arch of the cricoid cartilage and the subglottic space. The mass caused sufficient extrinsic pressure, or extended superiorly, with resulting distortion and fixation of the intrinsic larynx on the left, elevation of the laryngeal ventricle, and broadening of the

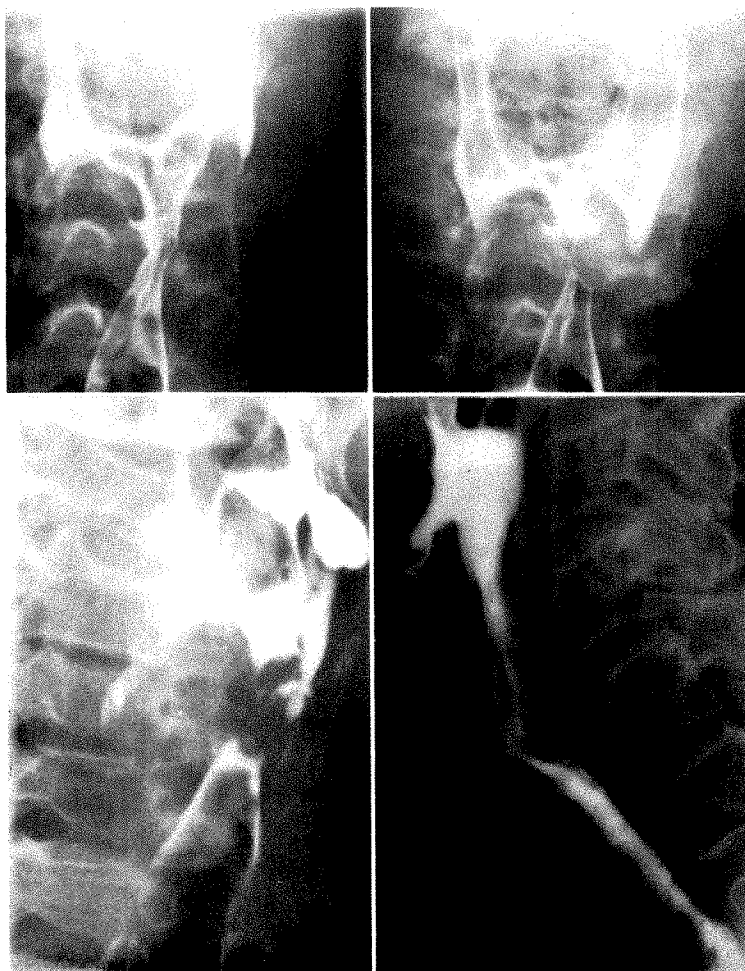


FIG. 9. Case IX. Carcinoma of the right vocal cord (see text).

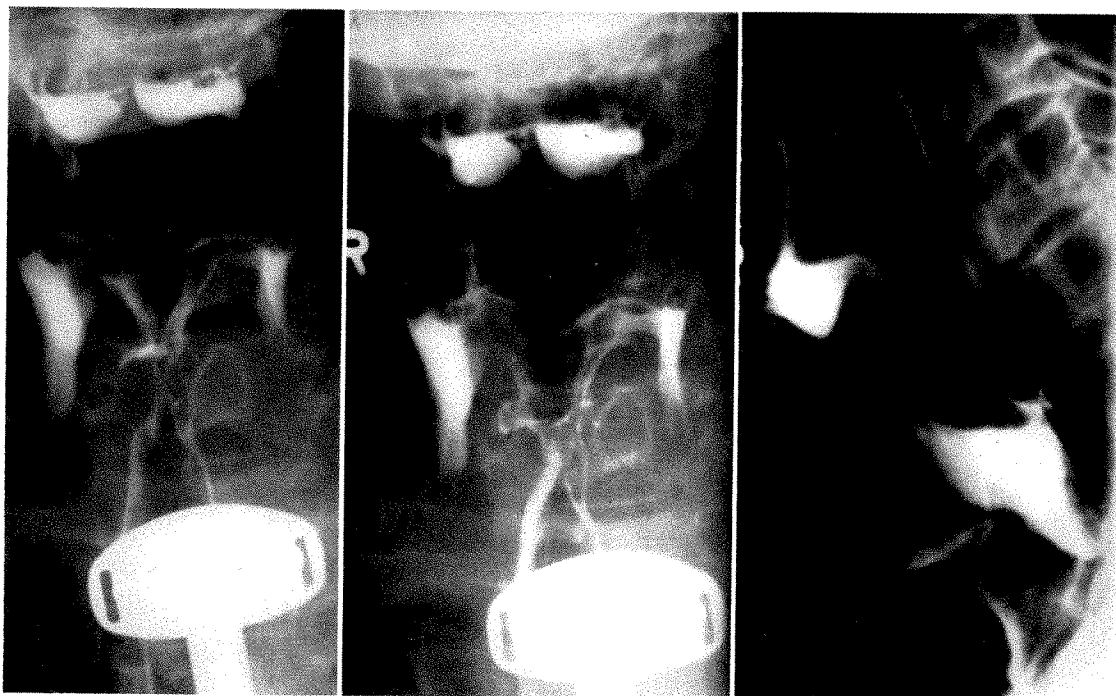


FIG. 10. Case x. Subglottic extension of carcinoma of the glottic region of the larynx.

arytenoid eminence. The left pyriform sinus was widened and its inferior angle was blunted.

Subsequent exploratory surgery demonstrated a primary adenocarcinoma which arose in the wall of the subglottic trachea.

CASE XII. (Fig. 12.) This sixty-nine year old male complained of a chronic cough for two years, and a persistent sore throat and hoarseness for three months prior to admission. Direct laryngoscopy revealed a large tumor mass involving the left pyriform sinus, with resulting distortion by extrinsic pressure of the vestibular walls and the false and the true cords on the left side. The glottic slit was narrowed, and although motion was demonstrated on the right, there was fixation of the left side of the intrinsic larynx. No evidence of subglottic extension was noted. The pathologic diagnosis was squamous cell carcinoma.

On the laryngogram, the extent of the lesion was evident. The left pyriform sinus was found to be obliterated by the tumor mass during quiet inspiration, and was only observed during the phonation maneuver. The irregular, distorted, and blurred medial wall of the hypopharynx defined the position and the lateral margin of the neoplasm. Involvement of the true and false

cords with obliteration of the laryngeal ventricle on the left was due to extrinsic pressure with some extension by the tumor, as was the asymmetry of the subglottic arch. The patient was treated with a radical course of radiation therapy.

CASE XIII. (Fig. 13.) One year following radiation therapy for carcinoma of the larynx, this sixty-six year old male had a recurrence in the right pyriform recess. This continued to progress until December, 1960 when on laryngoscopy a friable and necrotic tumor was demonstrated which involved the entire right side of the supraglottic larynx and pyriform sinus. In addition, the mass now involved the epiglottis and the left pyriform recess. However, the vocal cords could not be seen clearly, nor could the subglottic area be adequately assessed.

Laryngograms revealed marked distortion of the structures of the hypopharynx and larynx, involvement of both pyriform sinuses, particularly on the right, and loss of the vestibular landmarks. The epiglottis was rotated and fixed along the left aryepiglottic fold. Mobility of the false and true cords on the right side was noted, but there was almost complete fixation of the glottis on the left. Extension of the tumor into

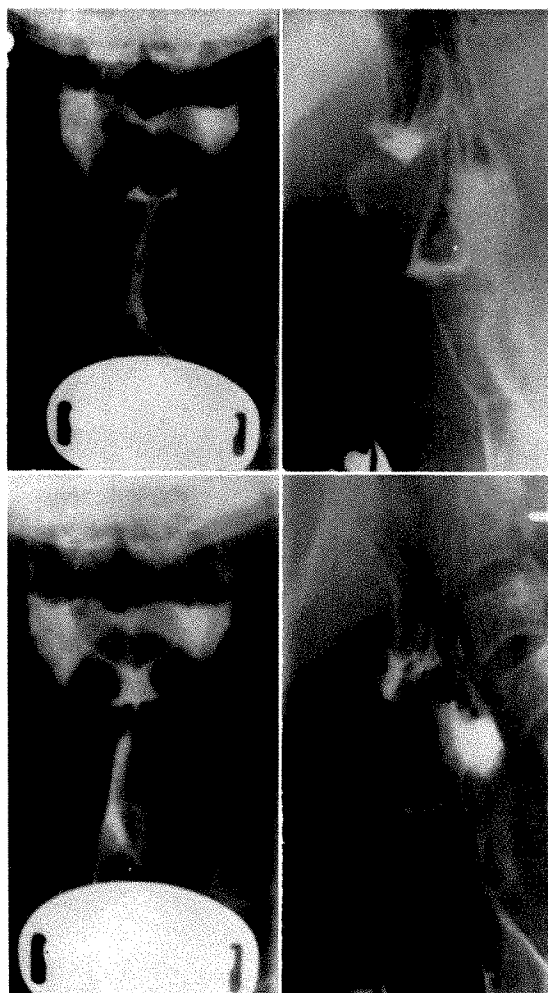


FIG. 11. Case XI. Carcinoma arising in the subglottic trachea.

the left subglottic region was evident; bulging on the right side was probably due to extrinsic pressure extending from the hypopharynx.

DISCUSSION

Although the recognized clinical methods remain the basis for diagnosis of laryngeal cancers, certain limitations may prevent the otolaryngologist (1) from determining the size and position of the tumor mass, and (2) from establishing the degree of extension and the clinical variety. Additional information may be obtained from lateral soft-tissue roentgenograms of the neck and frontal laminagraphic studies, particularly when the lesion develops primarily in the sagittal and coronal planes.

It is believed, however, that contrast laryngography has demonstrated its enormous value as an important adjunctive diagnostic procedure for the study and evaluation of the pathologic anatomy and abnormal function of the hypopharynx and larynx when cancers arise in these structures.

This safe yet effective technique of roentgenographic visualization of the larynx should permit the use of contrast laryngography in all patients with laryngeal disease with minimum risk. It is hoped that by the widespread practice of contrast laryngography as an adjunctive diagnostic measure to the clinical evaluation of the patient with cancer of the larynx, a true perspective of the pathologic anatomy will be

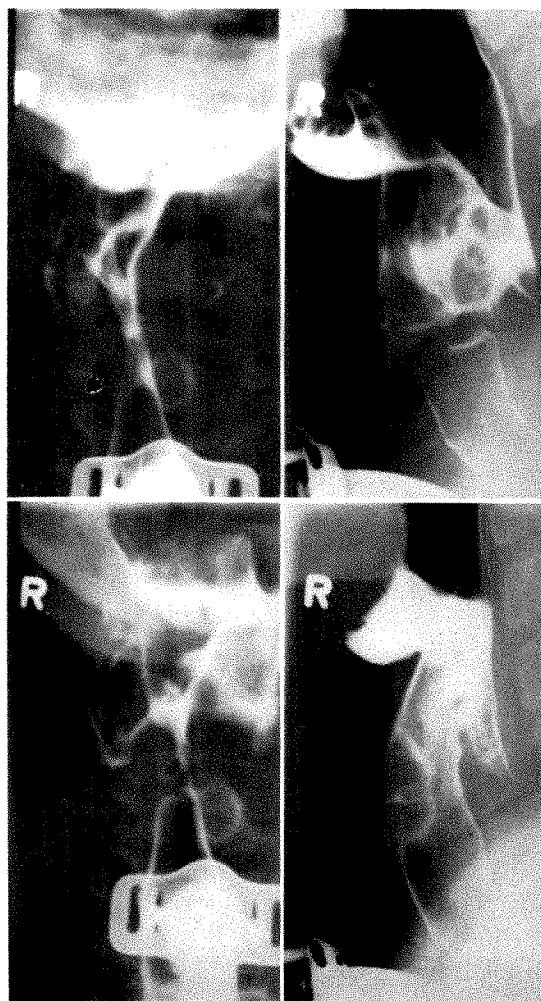


FIG. 12. Case XII. Carcinoma of the pyriform sinus.

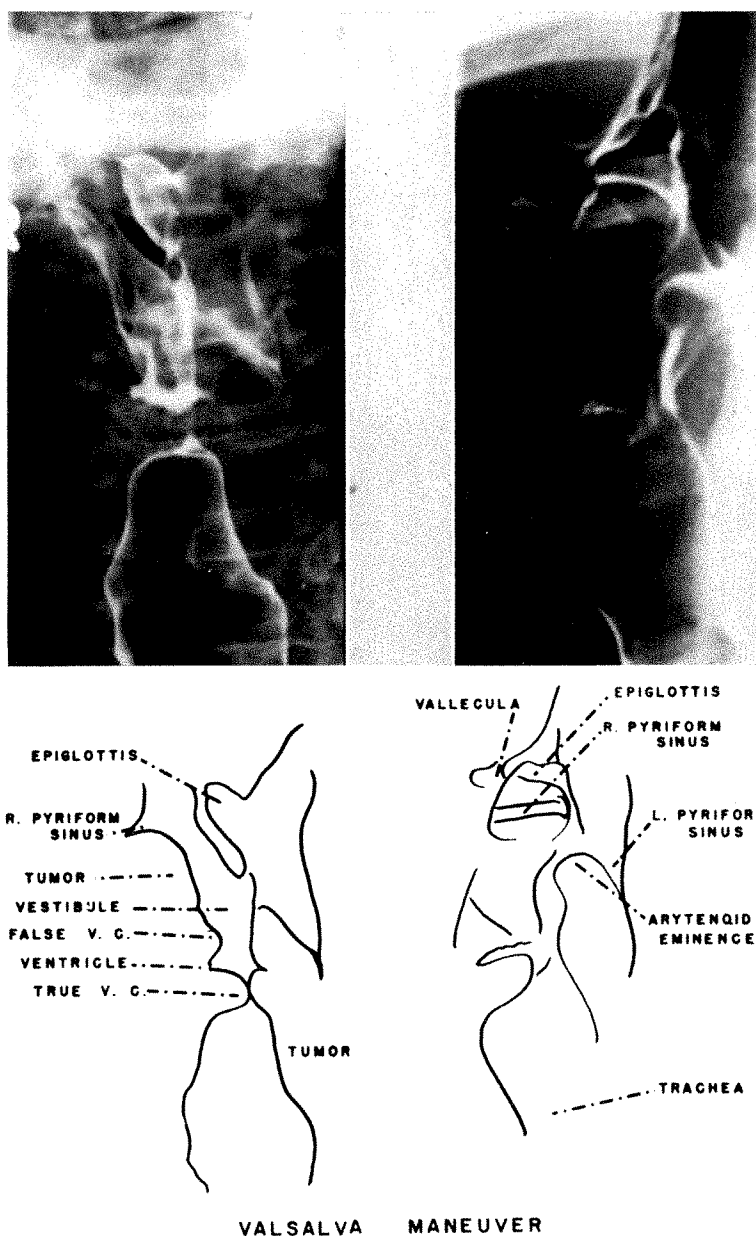


FIG. 13. Case XIII. Persistent carcinoma of the hypopharynx and larynx following radiation therapy (see text).

derived. This information may then be used to select, modify, and develop surgical and radiotherapeutic procedures to eradicate the disease and, subsequently, to evaluate the results of such treatment.

SUMMARY AND CONCLUSIONS

1. Contrast laryngography is performed as an adjunctive diagnostic procedure in the evaluation of the patient with cancer

of the larynx. This examination provides certain additional information to the otolaryngologist and radiotherapist which may not be obtained with conventional clinical and radiologic methods.

2. The technique of the procedure is described. It involves minimum risk, and may be carried out by the radiologist with the use of conventional fluoroscopic equipment. At The Johns Hopkins Hospital,

television image intensification fluoroscopy and cinefluorography have greatly enhanced the value of the examination.

3. Cases with various supraglottic, glottic, subglottic, and hypopharyngeal carcinomas are illustrated and discussed. The value of these studies to the surgeon and the radiotherapist is reviewed.

4. The use of contrast material to demonstrate the pathologic anatomy of the larynx and hypopharynx permits the radiologist (1) to accurately identify the position of neoplasms, (2) to determine the limits of the mass and possible extent of spread, and (3) to evaluate impaired function.

5. Laryngography is recommended as a routine technique in the evaluation of laryngeal cancers. It supplies information to the surgeon and radiotherapist and provides a sound basis for the use of existing therapeutic procedures or for the development of new techniques for the eradication of the disease.

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ANESTHESIA FOR BRONCHOGRAPHY UTILIZING INTERMITTENT POSITIVE PRESSURE BREATHING APPARATUS*

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A BRONCHOGRAM of diagnostic quality can be obtained only if the topical anesthesia is satisfactory. The adequacy of the topical anesthesia of the respiratory tract, both upper and lower, is therefore a major factor in diagnostic bronchography. At the Ohio State University Hospitals, bronchography is considered the most informative single diagnostic procedure, short of biopsy, in the differential diagnosis of the problematic pulmonary lesions found on routine chest roentgenograms.^{4,10} Since the maximum information is expected from this very helpful procedure, it is of utmost importance to assure good topical anesthesia in order to obtain bronchograms of highest quality.

Although more than 400 bronchographic examinations are performed annually in this center helping us to gain extensive experience with this procedure, the local anesthesia utilizing the usual method of spraying with an atomizer and swabbing with a pledget of gauze or cotton saturated with the anesthetic agent has remained a critical and often troublesome part of the examination. Anesthesia of the upper respiratory tract and the tracheobronchial system obtained by spraying of different anesthetic solutions is a tiresome, time-consuming procedure which requires special skill and experience in order to yield satisfactory results. It is distasteful to the patient because of the frequent gagging and coughing precipitated by the repeated spraying and swabbing of the pharynx and piriform sinuses. It would appear that the gagging and coughing during the anesthesia initiates a vicious cycle of easily precipitated, continued gagging and coughing

throughout the examination. Consequently, the examination is performed many times under difficult conditions with inadequate anesthesia. The inevitable result is an unsatisfactory bronchogram, which naturally offers little or no help in the solution of the diagnostic problem. We believe that the above major factors, all connected with local anesthesia, prevent both patient acceptance and a broader application of bronchography as a precise and valuable diagnostic tool. We believe that any technique which will provide more uniform anesthesia, down to and including even the small bronchi, will inevitably permit more complete visualization of the tracheobronchial system.

The purpose of this paper is to call attention to a simple and effective way to obtain more uniform anesthesia of the respiratory tract by utilizing the nebulizer of an intermittent positive pressure breathing apparatus (I.P.P.B.A.).

METHODS AND MATERIALS

The only premedication used was secobarbital, usually 75 mg. intramuscularly, given 60 minutes before the administration of the topical anesthesia, which can be accomplished equally well in the sitting or supine position (Fig. 1). Three cubic centimeters of lidocaine hydrochloride* 10 per cent solution mixed with propylene glycol and triton W. R., both 10 per cent by volume, are instilled into the nebulizer of a Bennett intermittent positive pressure breathing apparatus. The nebulizer breaks

* Lidocaine hydrochloride 10 per cent solution (xylocaine) was generously supplied for this study by the Astra Pharmaceutical Products, Inc., Neponset Street, Worcester 6, Massachusetts.

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Presented at the Sixty-second Annual Meeting of the American Roentgen Ray Society, Miami Beach, Florida, September 26-29, 1961.

the solution into fine particles the majority of which are $2-5\ \mu$ in size. The mist of these tiny droplets suspended in 100 per cent oxygen is inhaled under 5 cm. of water pressure. The patient is instructed to inhale slowly and deeply through the nose while occluding the tube with the tongue. Because of the small sized particles and the more than adequate oxygen supply during the procedure, the mist of the nebulized solution can be inhaled very comfortably in contrast to the gagging and coughing which is usually produced by the large droplets from the atomizer as they strike the pharynx. Only 12 minutes of continuous breathing of the nebulized anesthetic solution is required to achieve adequate and uniform topical anesthesia of the upper respiratory tract, with no discomfort whatsoever to the patient during the procedure. After the introduction of the catheter through the vocal cords, it is necessary to inject 6 to 8 cc. of 1 per cent lidocaine hydrochloride into the trachea, main stem bronchi and lobar branches.

RESULTS

Figure 2 demonstrates the result of anesthesia in 236 patients, which group comprises all the examinations performed since February, 1961 when this study was initiated. In 214 patients the catheter could

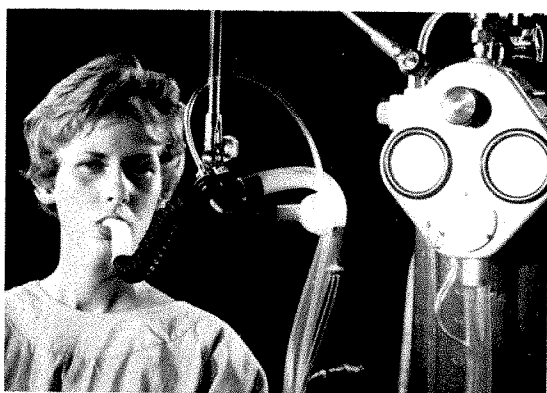


FIG. 1. Photograph illustrating the use of the intermittent positive pressure breathing apparatus in anesthesia of the respiratory tract in the sitting position. The method can be readily adapted to the supine position.

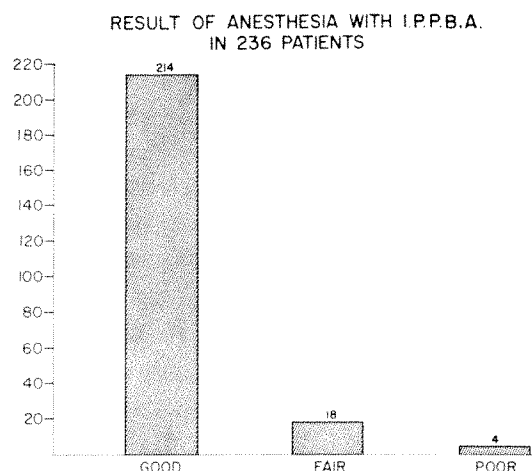


FIG. 2. Result of anesthesia with the use of the intermittent positive pressure breathing apparatus in 236 patients.

be introduced into the trachea without difficulty. In 18 others the vocal cords remained sensitive requiring the slow injection of an additional 1 cc. of 1 per cent lidocaine solution through the catheter directed to the vocal cords before the catheter could be advanced into the trachea. In 4 instances anesthesia had to be prolonged beyond 12 minutes because of technical difficulties. No side reactions were encountered which could be remotely related to this procedure.

DISCUSSION

According to studies of Landahl and his associates,⁶ nebulized particles larger than $6\ \mu$ in size fail to reach the alveolar ducts, being deposited on the pharyngeal, tracheal and bronchial mucosa by inertial impaction and sedimentation.^{5,6,8} The larger the size of the droplet, the more likely the early separation and deposition in the upper respiratory tract. Since the primary target of topical anesthesia for bronchography is the upper respiratory tract, the anesthesia of which requires larger than $6\ \mu$ particles, it is necessary to increase the size of the droplets by adding hygroscopic and surface-wetting agents to the anesthetic solution. They not only help to increase the size of the particles in the 100 per cent humidity

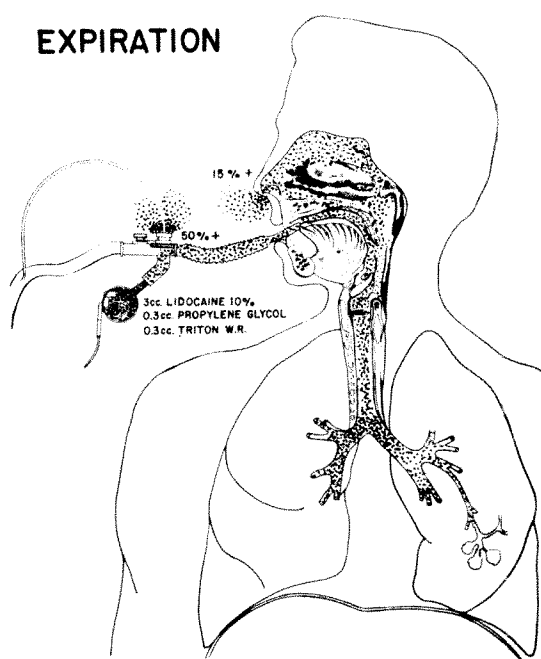


FIG. 3. Diagram illustrating the way in which the aerosolized anesthetic agent is lost. More than 50 per cent escapes during expiration through the exhaust valve and at least 15 per cent of the total solution is exhaled through the nose.

of the respiratory tract, but also reduce the surface tension of the tiny droplets, thus increasing the sedimentation and the formation of a coating layer of the anesthetic agent on the mucosa of the respiratory tract.

The amount of mist nebulized during the period of expiration escapes freely through the rubber flutter valve into the air. Since the duration of exhalation is generally longer than inspiration, it is safe to accept that less than 1.5 cc. of the 3.0 cc. anesthetic solution is actually inspired into the respiratory tract (Fig. 3). In our experience more than 15 per cent of the total amount of anesthetic solution nebulized will be exhaled through the nose. According to Miller and associates,⁷ who first advocated aerosol anesthesia for the respiratory tract, the procedure results in absorption of about 15 per cent of the nebulized solution. Therefore only 1 cc. (and probably considerably less) of the original 3 cc. of anesthetic solution can be

calculated as retained or absorbed in the respiratory system during the entire procedure which amounts to not more than 100 mg. of lidocaine hydrochloride as a maximum dose. Since it is usually necessary to inject an additional 6 to 8 cc. of 1 per cent lidocaine hydrochloride into the trachea, main stem bronchi and lobar branches after the introduction of the catheter through the vocal cords, the total amount of lidocaine hydrochloride retained in the respiratory tract does not exceed 160 to 180 mg.

The permissible intravenous dose of lidocaine hydrochloride is not more than 200 to 300 mg. in an adult of average weight.^{2,3,9} According to the studies of Astrom and Persson,¹ lidocaine is absorbed very slowly from the bronchial mucosa, and a 5 times greater dose can be used intratracheally than intravenously with safety (Table 1). These data indicate that the maximum retained amount of 160 to 180 mg. which we have been using in this procedure is well below the permissible dose of this agent.

The simplicity of this method should have considerable appeal to physician and patient alike. Special techniques, skills and instruments are not necessary. This technique of providing surface anesthesia requires only a brief period of time, only 12 minutes being necessary, and it creates a relatively uniform degree of anesthesia in nasal passages, pharynx, and larynx. After the catheter has been passed through the

TABLE I
RELATIVE TOXICITIES FOR THE DIFFERENT
ROUTES OF ADMINISTRATION*

Route	Tetracaine	Cocaine	Lidocaine
Intravenous	1.0	1.0	1.0
Intratracheal	1.0	1.8	5.1
Intranasal	2.7	3.5	8.7
Intravesical	5.1	22.0	40.0

* The relative LD₅₀ dose of tetracaine, cocaine, and lidocaine for the different routes of administration (after Astrom and Persson¹). All figures are related to the intravenous LD₅₀ dose which is accepted as a unit. It should be noted that the LD₅₀ dose of lidocaine intratracheally is 5.1 times greater than the intravenous dose.

vocal cords, an additional injection of more dilute anesthetic agent usually ensures thoroughly satisfactory anesthesia of the trachea, main stem bronchi, lobar and segmental branches.

There are at least 4 major obstacles to the introduction of an anesthetic agent into the respiratory tract which are of course the major defensive mechanisms of this system against any foreign body or material. They are: (1) swallowing reflex, (2) gag reflex, (3) cough reflex, and (4) the angulation between the mouth and the pharynx along with the contractions of the glottis. In apprehensive and disturbed patients these protective mechanisms seem to be even more sensitive and difficult to overcome. Consequently, one of the great advantages of this technique is the absence of discomfort and the freedom from gagging and coughing which often seems to carry over into the examination itself, making it less effective as a diagnostic procedure and at times completely unsatisfactory. The fact that we were able to pass the catheter without difficulty through the vocal cords in 214 patients out of 236 examinations is indicative of the high degree of effectiveness of this technique. Additional anesthesia applied directly to the vocal cords was required in only 18 patients. We would like to emphasize the safety of this technique in that we have not encountered any side reactions in 236 examinations.

CONCLUSIONS

In our experience, the administration of a topical anesthetic agent with the intermittent positive pressure apparatus is safe, time-saving, provides a more uniform, adequate anesthesia without causing discomfort to the patient and permits bronchographic examinations of the highest diagnostic quality.

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ADDENDUM

Following the presentation of this discussion at the Annual Meeting, this technique has been utilized in an additional 223 examinations with similar good results and without any complication.

We wish to express our thanks to Mrs. Kathryn Heinzerling, R.N., and Miss Maxine Duer, R.T., for their valuable assistance in this project.

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TRANSTRACHEAL BRONCHOGRAPHY*

COMPLICATIONS OF INJECTION OUTSIDE THE TRACHEA

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THE transtracheal method has become an increasingly popular technique for bronchography in the past few years. In view of the ease with which opaque material can be introduced into the tracheobronchial tree and the lack of serious anesthesia reactions, this method is considered to be the most satisfactory by many authors.

Extravasation of dionosil (either oily or aqueous) into the peritracheal tissues has been mentioned by Beck and Hobbs¹ and was not considered to be significant. This is the only previous mention of injection outside the trachea that we could find in the radiologic literature.

The following is a summary of 7 cases in which the symptoms produced by the extravasation were serious enough to lengthen the patient's hospital stay and to cause considerable anxiety for the attending physicians.

REPORT OF CASES

CASE I. A fifty-five year old male entered the hospital on February 3, 1960 with symptoms of fever, cough and dyspnea. Physical examination revealed rales at both lung bases and elevated temperature. On the following day bilateral bronchography was attempted utilizing the intranasal catheter method. This procedure was unsatisfactory due to the patient's gag reflex.

On February 5, 1960 bronchography was performed using the transtracheal route. Following the injection of xylocaine, a No. 17 gauge needle was inserted into the trachea and 10 cc. of aqueous dionosil was injected. Bronchograms were immediately obtained and revealed poor filling of the bronchi. Contrast material was noted in the soft tissues at the injection site anterior to the thyroid cartilage.

During the next twelve hours the patient developed marked redness and tenderness at the injection site. There were no other findings re-

lated to the extravasation of the contrast material. The neck tenderness and redness persisted for approximately seven days and the patient recovered uneventfully.

On February 16, 1960 bronchography was performed via the cricothyroid route without difficulty. There was excellent filling of the bronchial tree and subsequent bronchograms revealed cylindrical bronchiectasis of the left lower lobe bronchi.

CASE II. The patient was a forty-six year old obese white male who had been complaining of cough and productive sputum for several years. On May 23, 1957 bronchography was performed.

After preliminary anesthesia, the transtracheal needle was inserted. It was noted by fluoroscopy that some of the contrast medium had extravasated into the neck, probably about 8 cc.; however, examination was continued and a satisfactory visualization of all major divisions of the tracheobronchial tree was obtained. The examination showed no abnormality in the bronchial structure.

Immediately after examination, the patient complained of some pain in the neck and dysphagia, but he was allowed to go home. On the next day, the patient was admitted to the hospital complaining of "choking" and pain in the chest. No elevation of temperature was noted. There was some dyspnea. The patient stayed in the hospital about twelve days, during which time there was a gradual systematic improvement. He was treated with antibiotics, cortisone and supportive therapy. Roentgenograms of the chest showed opaque medium in the upper thoracic and lower cervical region.

After discharge from the hospital, there was still some complaint of swelling in the lower neck and pain. Roentgenograms taken on June 25, 1957, approximately one month after the bronchographic examination, showed about 95 per cent absorption of the oily dionosil. By July, 1957 the patient was well and a roentgen study obtained on August 2, 1957 showed complete absorption of the dionosil.

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CASE III. A two and one-half year old female child was referred to the x-ray department for bronchography. She was being studied because of repeated pneumonitis and recently had been bronchoscoped. Rather than subject the child to a second anesthesia, the transtracheal method was attempted, but she would not cooperate and a bronchogram was not obtained. About 4 cc. of oily dionosil was injected into the peritracheal tissues (Fig. 1).

The following day there was a temperature rise to 101.5° F., neck rigidity and swelling. The child was severely ill for approximately one week and then gradually improved. Serial roentgenograms showed dionosil in the soft tissues of the neck and in the upper thorax in gradually decreasing amounts. After about six weeks the material had been completely absorbed as seen on roentgenograms.

CASE IV. The patient was a thirty year old white female with a history of hemoptysis. On June 2, 1960 bronchoscopy was done without significant findings except slight redness of the



FIG. 1. Case III. Dionosil (about 4 cc.) in the fascial planes of the neck four days after injection.

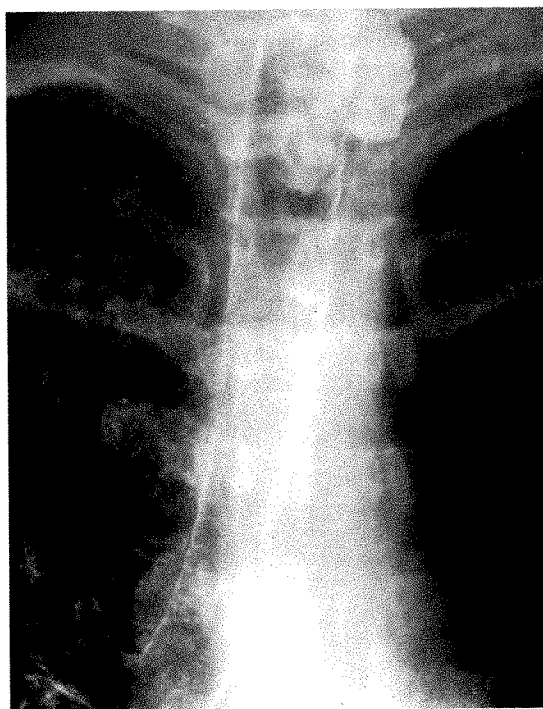


FIG. 2. Case IV. Dionosil (about 3 cc.) in the neck to the left of the trachea.

right upper lobe bronchus. On June 7, 1960 transtracheal bronchography was performed under fluoroscopic control. About 3 cc. of the contrast medium was extravasated (Fig. 2) following the filling of a normal right bronchial tree. The examination was immediately discontinued. The following day there was marked tenderness in the neck with redness and swelling. The symptoms gradually subsided after four to five days. The patient refused to have the left side of the bronchial tree filled at a later date.

CASE V. A forty-three year old white female was admitted to the hospital and on March 15, 1960 transtracheal bronchography was attempted. Most of the dionosil (estimated 8-10 cc.) was injected outside the trachea. Roentgenograms taken following the procedure showed extravasation of the material well down in the anterior mediastinum. The patient was discharged the following day and was readmitted on March 17, 1960 with a temperature of 100.5° F. and marked soreness and swelling in the neck. Considerable dyspnea and chest pain were also present. On March 18, 1960 an electrocardiogram showed T wave inversion in all leads. A repeat electrocardiogram on March 19, 1960 showed further changes consistent with

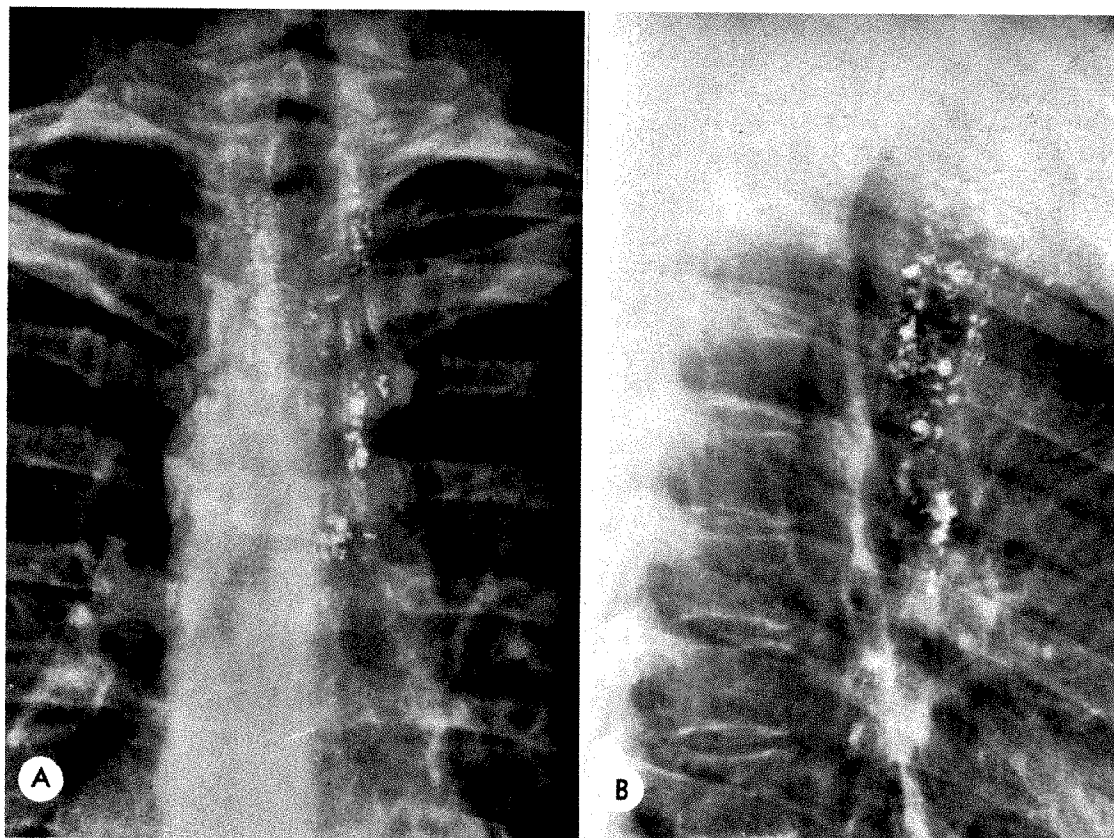


FIG. 3. Case v. (A) Anteroposterior and (B) lateral projections showing extravasated dionosil persisting ten weeks after the peritracheal injection of 8-10 cc. of the medium. Notice how far down the mediastinum the material penetrated.

pericarditis. The marked pain in the neck and chest persisted for two weeks. Therapy consisted of antibiotics, cortisone and general supportive care.

The patient was finally discharged on April 1, 1960 relatively asymptomatic, but roentgen evidence of the extravasated medium persisted for some time (Fig. 3, A and B).

CASE VI. The patient was a fifty-four year old white female who had had a thoracoplasty for tuberculosis in 1952. She was hospitalized because of hemoptysis. On August 11, 1959 bronchography was performed by the transtracheal route. During the procedure, 3-4 cc. of oily dionosil was extravasated at the puncture site anteriorly in the region of the thyroid isthmus.

The following day there was pain in the neck, swelling, fever and chills. The temperature was 101° F. She was treated with salicylates, par-enzyme, antibiotics and varidase buccal. On August 17, she was considerably improved and afebrile; the neck was less swollen and less

tender. The thyroid gland was definitely palpable and enlarged and remained so for approximately one month following the bronchographic procedure.

The acute symptoms in this case lasted six to seven days and, for the main part, were due to a thyroiditis.

CASE VII. A forty-seven year old white male was sent to the radiology department for bronchography because of hemoptysis. During the transtracheal instillation, about 6 cc. of dionosil was injected outside the trachea (Fig. 4, A and B). The patient was put on large prophylactic doses of ACTH. Severe pain, redness and swelling occurred in the neck approximately forty-eight hours following the procedure.

These symptoms lasted six to seven days before gradual alleviation. The patient did not have to be hospitalized.

DISCUSSION

Since we have noticed significant clinical reaction in practically every case where

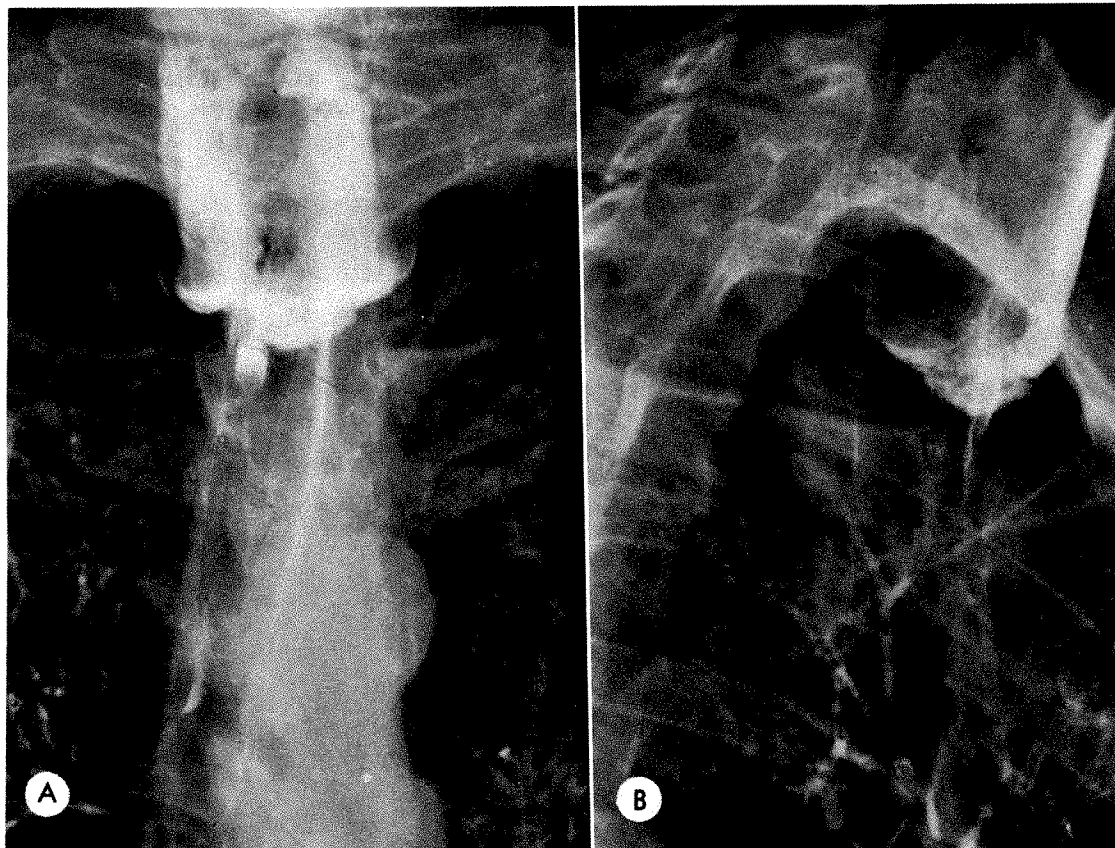


FIG. 4. Case VII. (A and B) Dionosil (about 6 cc.) anterior to the trachea following the injection.

dionosil was injected inadvertently outside the trachea, it was felt that these cases should be reported. As stated above, Beck and Hobbs¹ mentioned 1 case of soft tissue infiltration without serious consequence.

Aside from the general supportive measures for pain relief (hot compresses, etc.), we believe that ordinary doses of cortisone or ACTH for a few days following the soft tissue infiltration are helpful.

It is felt that transtacheal bronchography is unwise in children because of their small trachea and lack of cooperation.

CONCLUSIONS

1. Seven cases of peritracheal dionosil extravasation are reported. The symptoms produced varied directly with the amount of material outside the trachea. Cellulitis, thyroiditis, mediastinitis and pericarditis

may be produced. One case (Case v) showed symptoms and changes of all these entities.

2. Since larger extravasations cause more symptoms, fluoroscopic control is suggested during the transtacheal injection. A polyethylene tube attached to the syringe will help avoid motion of the needle during the procedure.

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TRACHEAL COLLAPSE IN POLYCHONDritis

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WITHIN the past year there have been 2 patients who have been hospitalized at the University of California Los Angeles Medical Center with a generalized degenerative and inflammatory disease of cartilage. Both patients died of respiratory obstruction due to collapse of the tracheal cartilages. Roentgenograms had demonstrated the tracheal narrowing in each patient.

Pearson, Kline, and Newcomer² of UCLA reviewed this disease in 1960 under the title "Relapsing Polychondritis." They located 10 previous cases in the world literature and added 2 more. One of their cases has died since their report and is included here. Bean *et al.*¹ also have written a recent article on this disease titled "Chronic Atrophic Polychondritis."

The disease presents clinically with recurrent episodes of inflammation of various cartilaginous structures. There is eventual destruction and collapse of the cartilages leading to functional difficulties. The trachea, larynx, nose, and external ears are most commonly affected. The epiglottic, bronchial, articular, and costochondral cartilages have been involved in some patients. Iritis, episcleritis and deafness due to inner ear disease have been reported in conjunction with this condition.

REPORT OF CASES

CASE 1.* In January of 1958 this patient was twenty-nine years old and was three and one-half months pregnant. She developed acute pain, redness, and swelling of both external ears, vertigo and deafness, and episcleritis of the left eye. These symptoms responded well to adrenal steroids except for the deafness, which persisted. In July, 1958 a normal full-term infant was delivered.

Steroid therapy was maintained. Steroid dosage was reduced or discontinued several times

and each time her ears became inflamed. The external ears eventually became soft and flabby, and the auditory canals became stenotic. She also had a chronic cough and episodes of hoarseness, dyspnea, and tenderness over the trachea and costochondral cartilages.

In July, 1960 she was hospitalized with pneumonia. After treatment with penicillin roentgen studies demonstrated clearing of the pneumonia. Despite this, she became more dyspneic and a tracheotomy was performed. She suffered a temporary cardiac arrest during the operation and died two days later.

Pathologic Findings. Biopsy of the ear cartilage on May 4, 1959 showed normal cartilage cells with degeneration of the matrix which had



FIG. 1. Case 1. Laminagram of the trachea and larynx demonstrating narrowing of the upper trachea.

* This is Case 11 of Pearson *et al.*²

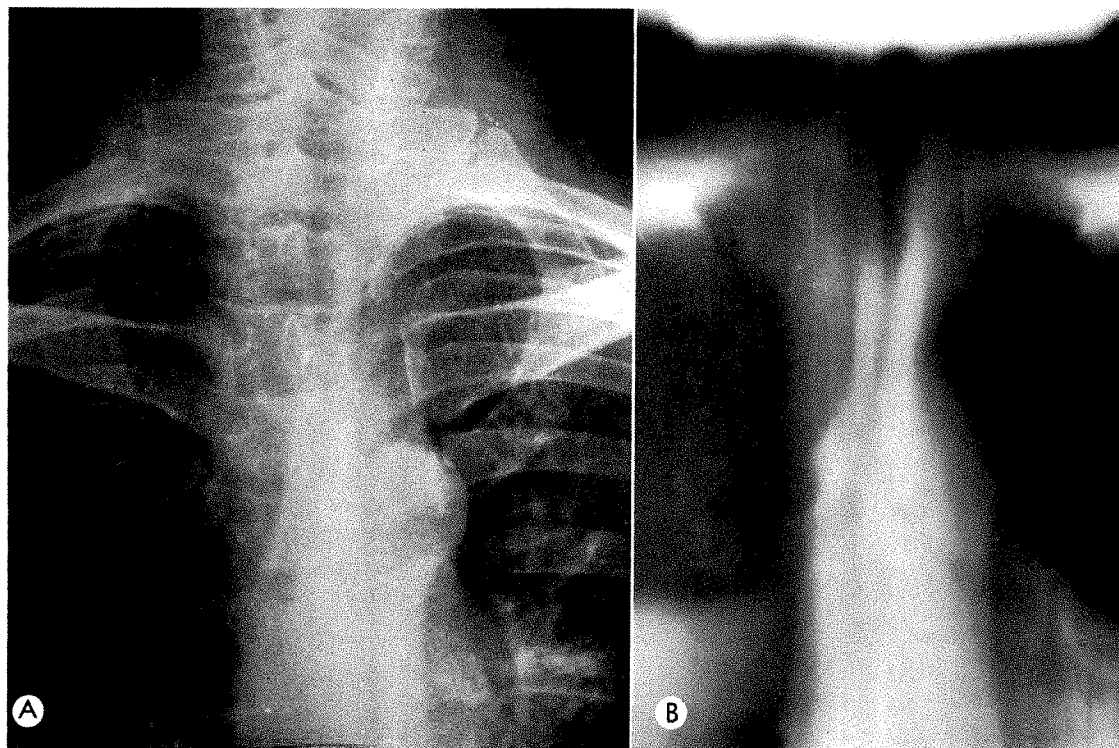


FIG. 2. Case II. (A) Plain chest roentgenogram and (B) laminagram demonstrating tracheal narrowing.

lost its normal basophilia and was eosinophilic and opaque. The margins were invaded by fibroblasts, blood vessels, and inflammatory cells.

Autopsy findings included narrowing of the glottic opening, thickening of the epiglottis and aryepiglottic folds, and narrowing of the trachea. The cartilaginous rings had disappeared in a portion of the trachea making the structure soft and collapsible. There was pulmonary edema, atelectasis and bronchopneumonia.

Microscopic examination of sections from the trachea showed a loss of normal cartilaginous architecture. The tracheal rings were thin and fragmented, and the basophilic matrix had been replaced by acidophilic material. There were numerous areas of chronic inflammatory infiltration and fibroblastic reaction. Similar but less marked changes were seen in the cartilages of the epiglottis, larynx and bronchi. There were minimal changes in the costochondral cartilages consisting of fibrillation and cleft formation.

Roentgen Findings. Roentgenography and laminagraphy of the trachea in July, 1960

(Fig. 1) demonstrated narrowing of the upper segment of the trachea.

CASE II. This fifty-nine year old white, married female began having episodes of wheezing, dyspnea, and cough in May, 1960, which were felt to be asthmatic attacks and were treated as such. In October, 1960 she was hospitalized for "status asthmaticus." Bronchoscopy, however, revealed tracheal stenosis. Following this episode, she was constantly short of breath and had an inspiratory stridor. Despite treatment with steroids, her respiratory difficulties became progressively worse. Pulmonary function tests demonstrated severe obstruction to ventilation. Tracheotomy was performed on February 21, 1961. Despite this, she died soon afterwards.

Of interest in her history was a saddle nose deformity which had appeared following trauma. She had experienced arthritic pains in her back and extremities for twenty years.

Pathologic Findings. Tracheal biopsy on February 7, 1961 showed thick, fibrous tissues around the trachea with degeneration of the cartilaginous rings.

At autopsy the trachea and major bronchi

showed concentric narrowing throughout. The structures had lost their resilience and the cartilaginous rings were small and flaccid. The lungs were emphysematous and the small bronchi were filled with mucus. The cartilaginous rings of the trachea and bronchi were acidophilic and showed marked degeneration. There was dense fibrous tissue surrounding the trachea and bronchi with foci of inflammation in the cartilage. The cartilages of the larynx and nasal septum showed similar degenerative and inflammatory changes. The costal cartilages were also mildly involved by an inflammatory chondrolysis. Cartilage from the ear, epiglottis, and knee was normal.

Roentgen Findings. Plain roentgenography and laminagraphy on January 31, 1961 (Fig. 2, *A* and *B*) demonstrated marked narrowing of the entire trachea and the larger bronchi.

COMMENT

A third case of polychondritis (Case 1 of Pearson *et al.*²) also has been seen at the UCLA Outpatient Clinic, but it has pre-

sented no demonstrable involvement of the trachea or larynx. Although there have only been 13 reported cases of this disease, the fact that 3 of them have been seen recently at UCLA suggests that the disease is often undiagnosed or unreported.

Radiologists should be aware that polychondritis may cause collapse of the respiratory cartilages and difficulties with breathing. In both of our hospitalized cases, the tracheal narrowing was visible on the plain chest roentgenograms.

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GRANULOMATOUS LUNG REACTION FOLLOWING REPEAT BRONCHOGRAPHY WITH PROPYLIODONE*

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THE development of a granulomatous reaction in the lungs after bronchography is a very infrequent occurrence. Nevertheless, during the past several years a few cases with iatrogenic lesions of this type following the instillation of various oily or aqueous contrast media have been reported.

With the oily substances, the oil itself is apparently responsible for the "foreign body" type of response. Indeed, Fischer⁵ maintains that retention of oil in the lung parenchyma for more than ninety days will consistently be followed by granuloma formation. With the aqueous contrast agents, Dunbar *et al.*⁴ have recently pointed out that depending on which agent is used the retention of either the radiopaque material itself, *e.g.*, barium sulfate, or some component in the vehicle, as high concentrations of carboxymethylcellulose, has in the past been held responsible for granulomatous reactions. Consequently, one of the desiderata of a good bronchographic contrast medium is that it be rapidly and completely eliminated from the body. Two of the media in current use which meet this requirement and are also relatively free of undesirable side effects are a 60 per cent suspension of propyliodone in peanut oil (dionosil oily) and a 50 per cent aqueous suspension of the same product (dionosil).^{*} The vehicle in the aqueous preparation contains carboxymethylcellulose, which imparts the desired degree of viscosity to the suspension, and also small amounts of sodium citrate, sodium chloride, polyethylene glycol, 600 mono-oleate, and benzyl alcohol.

* Both Dionosil Oily and Dionosil are products of Glaxo Laboratories Ltd.

With regard to the first of these media, Holden and Cowdell⁸ have reported that over a five year period they found no late clinical reactions to dionosil oily and no demonstrable damage of tissues removed at surgery. Similarly, there have been no reports of late clinical reaction or tissue damage after the use of the aqueous preparation.

Recently, however, a case was seen in which a pronounced granulomatous reaction followed the second of 2 bronchographies with propyliodone. Dionosil (aqueous) was used for the first bronchography and dionosil oily for the second.

REPORT OF A CASE

The patient (M.M.H. #3999978) was a forty-nine year old white woman who was first admitted to the Massachusetts Memorial Hospitals on January 19, 1959 with a twenty-four hour history of severe hemoptysis. For ten years prior to admission she had had frequent upper respiratory infections, including bouts of pneumonia, but coughing had never been a prominent symptom. There had been one episode of hemoptysis six years previously. No history of allergy or exposure to tuberculosis was elicited. Physical examination was essentially negative. A first strength purified protein derivative tuberculin skin test was negative. Repeated cultures and guinea pig inoculations of sputum and gastric washings were negative for acid fast bacilli, as were numerous sputum smears. Routine chest roentgenograms were normal. The patient was bronchoscoped shortly after admission and brisk bleeding from the left upper lobe orifice was noted. The bleeding subsided spontaneously within a few hours, and three days after admission a bronchogram (Fig. 1) was made following instillation of 20 cc. of dionosil (aqueous). The roentgenologic diagnosis was minimal bronchiectasis of the lingula.

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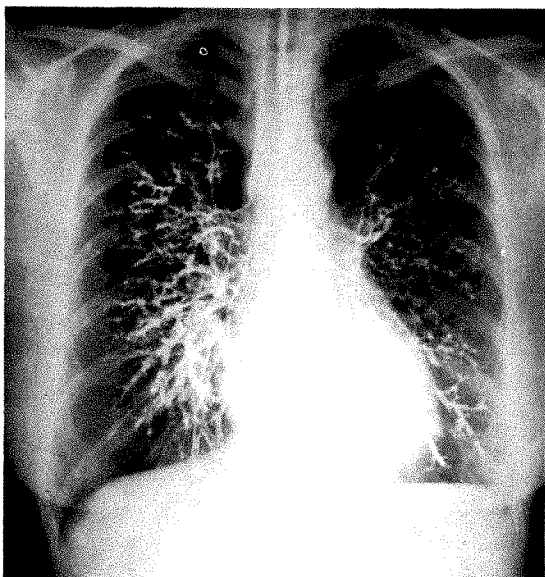


FIG. 1. Initial bronchogram following instillation of dionosil (aqueous). There is minimal dilatation of bronchi in the lingula.

Bleeding did not recur and the patient was discharged seven days after admission.

Two months later on March 16, 1959 the patient returned to the hospital after another episode of hemoptysis. Routine chest roentgenograms and laminagrams (Fig. 2) were con-



FIG. 2. Laminagram, two months after the first bronchogram, showing no abnormality.

sidered within normal limits. No residual radiopaque medium was seen. The bleeding persisted and on the day after admission a left exploratory thoracotomy was performed.

At operation, numerous fibrous adhesions were noted between the visceral and parietal pleura, particularly over the lingula and between the lower lobe and the diaphragm. The lingula was collapsed, firm and "rubbery," but the remainder of the left lung appeared negative except for the adhesions. Lingulectomy was performed. The postoperative course was uneventful and the patient was discharged on the twelfth postoperative day.

Pathologic examination revealed slight to moderate bronchiectasis, chronic pneumonitis with focal fibrosis, slight to moderate congestion, and small areas of atelectasis. There was no granulomatous inflammation.

Approximately eight months after lingulectomy, the patient was again hospitalized (November 4, 1959) because of another episode of hemoptysis, during which she coughed up about 3 tablespoonfuls of bright red blood. A routine chest roentgenogram was negative (Fig. 3). The next day bronchography was repeated, but this time dionosil oily was em-

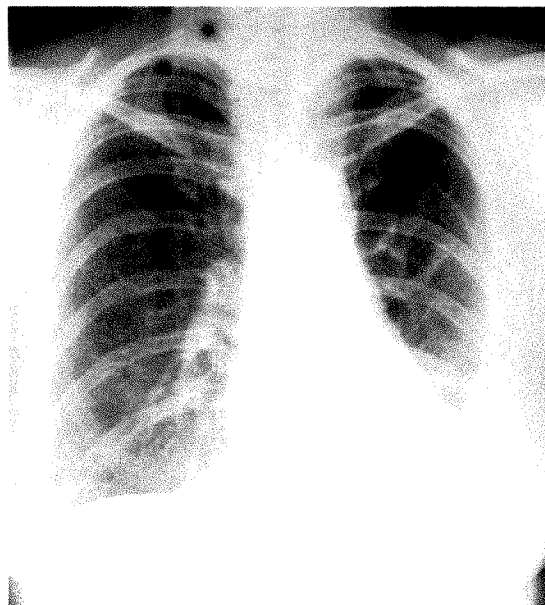


FIG. 3. Posteroanterior chest roentgenogram eight months after the initial bronchogram and one day before the second bronchogram shows a density in the second left anterior interspace which was believed due to pleural thickening; otherwise, the roentgenogram is negative.

ployed. Changes suggesting cystic and saccular bronchiectasis of the left lower lobe were visualized on the bronchograms. Hemoptysis did not recur and there was no change in the patient's symptoms or physical findings after bronchography. Four days later, a left lower lobectomy was performed.

At operation there was pleural symphysis and the left upper and lower lobes were mobilized only after a tedious and bloody dissection. On palpation, the lower lobe was markedly nodular, somewhat suggestive of tuberculosis, and small, apparently bronchiectatic, pockets of pus were encountered between the lower lobe and the diaphragm. Smears and cultures of this material were negative for acid fast bacilli.

Gross pathologic examination of the operative specimen revealed the irregularly thickened



FIG. 4. Marked granulomatous inflammation around a terminal bronchiole. Note the Langhans type giant cells in the lower part of the photomicrograph. Hematoxylin and eosin ($\times 165$).

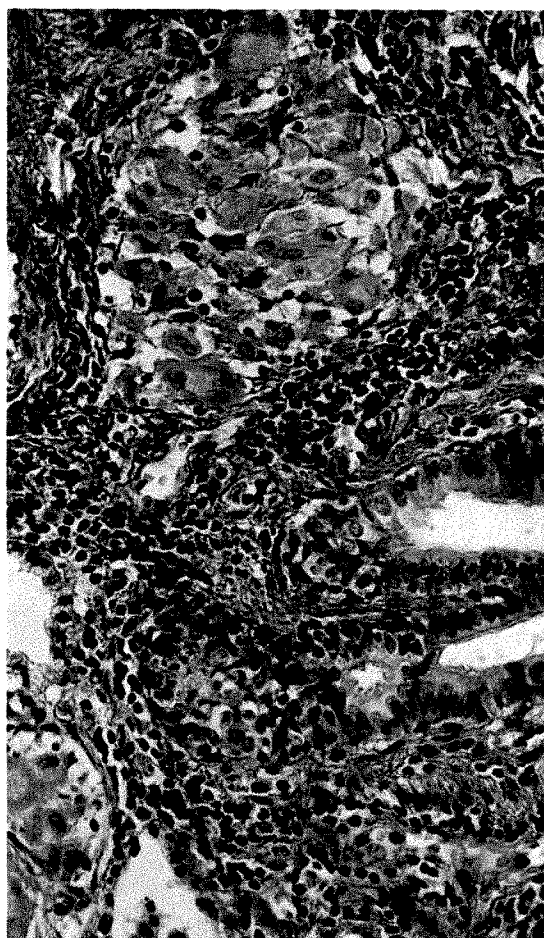


FIG. 5. Higher magnification of the area seen at the lower left in Figure 4. The bronchiolar lumen is occluded by lymphocytes and macrophages. Hematoxylin and eosin ($\times 300$).

pleural surface, a slight to moderate degree of bronchiectasis, and numerous firm nodules up to 1 cm. in diameter with pale cut surfaces and somewhat irregular outlines. Microscopically, the most striking finding was the presence of granulomatous inflammation adjacent to terminal bronchioles (Fig. 4 and 5). The latter were often compressed or occluded by granulomata composed of macrophages or epithelioid cells and numerous giant cells of both the Langhans and foreign body types. For the most part the cytoplasm of the macrophages was finely granular and not vacuolated (Fig. 6). There was no necrosis in the involved areas, and no inclusions were seen within giant cells. In specially stained preparations neither acid fast bacilli nor fungi were identified. Periodic acid-Schiff stains showed a very small amount of

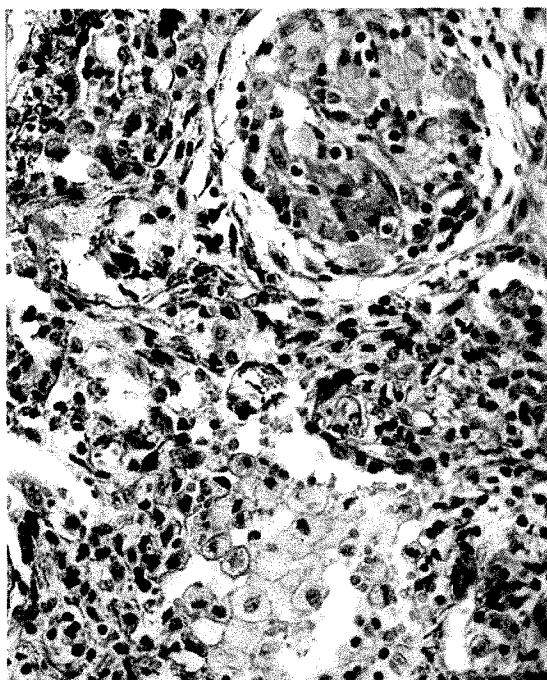


FIG. 6. Granuloma composed of macrophages is seen in the upper central part of the field, and numerous "foamy" macrophages in an alveolar space are seen in the lower center. Hematoxylin and eosin ($\times 300$).

PAS-positive material in some giant cells and macrophages. In most sections the granulomatous inflammation did not extend to the pleural surface and variable amounts of essentially negative lung parenchyma were seen in the more peripheral portions of the lung.

Frozen sections prepared from formalin fixed tissue and stained with Oil Red O revealed several clusters of lipid-laden macrophages in alveoli, bronchioles, and interstitial tissue. The aggregates of macrophages containing Oil Red O, however, were located primarily *between* granulomata, although some lipid was also demonstrated within a few granulomata in giant cells and macrophages (Fig. 7). The stainable lipid was present as fairly uniform, small to medium size droplets. A very small amount of lipid not contained in macrophages was seen in alveoli. Frozen sections of formalin-fixed tissue stained with Feyrter's tartaric acid-thionin mixture (according to Pearse⁹) were found to have a small amount of deep rose-pink material within macrophage in some of the granulomata. In addition, however, the cells lining the submucosal bronchial glands stained intensely rose-pink, as did the material in gland lumina.

The proximal bronchial tree was relatively free of granulomatous inflammation, although there was dilatation of many bronchi and of some of the larger bronchioles, together with peribronchial fibrosis and infiltration by a variable number of lymphocytes and plasma cells. Eosinophils were few. Occasionally, small granulomata were seen at these sites as well, but they were not comparable in number or size to those involving the more distal portions of the bronchial tree. Peribronchial lymph nodes contained moderate numbers of macrophages, some of which had finely vacuolated or "foamy" cytoplasm, but no giant cells were seen.

DISCUSSION

In the absence of any histologically demonstrable infectious agent in the resected lung tissue and without positive bacteriologic findings on samples of sputum and gastric washings, the granulomatous lesions found in the lower lobectomy specimen are perhaps best explained as a reaction to the instillation of dionosil oily during the second bronchography. Similar



FIG. 7. Stainable lipid within macrophages appears black in this photomicrograph of an area of granulomatous occlusion of a bronchiole. In the upper center the lipid is within a giant cell. Oil Red O stain ($\times 100$).

lesions were not present in the first surgical specimen, removed two months after bronchography with dionosil (aqueous). Moreover, there were no nodular densities seen on the chest roentgenogram taken the day before the instillation of dionosil oily, although some of the nodules in the second operative specimen were certainly large enough to have been seen on roentgenograms had they been present.

The absence of granulomata in the first surgical specimen is in accord with the experimental results of Björk and Lodin,¹ who failed to produce granulomatous lesions in the lungs of 4 rats by the intratracheal injection of dionosil (aqueous), although granulomata were induced by the introduction of other media containing higher percentages of carboxymethylcellulose. Dunbar *et al.*⁴ also failed to find any granulomata when rats were sacrificed at one day, seven day, twenty-eight day, and four month intervals after the intratracheal instillation of dionosil (aqueous).

On the other hand, Björk and Lodin² found that the intratracheal injection of dionosil oily produced a few small foreign body granulomata in 3 of 10 rabbits at the end of three months, and a greater number of larger granulomata in 7 of 10 rabbits at the end of six months. This increase in granulomatous reaction with increasing duration of oil retention recalls the statement of Fischer on the inevitability of such a response to retained oil. However, it also underscores the importance of time in the development of this reaction.

In man, Holden and Cowdell⁸ could find no evidence of this delayed effect of dionosil oily. They suggest that anatomic and physiologic differences between rabbits and humans and the difference in the technical approach to bronchography in the 2 species may account for the discrepancy. Detailed histologic examination of lung tissue, resected from 49 of their patients with nontuberculous bronchiectasis after one or more bronchographies, revealed only a small amount of fatty material and rare foreign body granulomata. There was

"no fat staining material in any of the granulomata observed."⁸ Operation was performed from one week to four years after bronchography. No cases are mentioned in which bronchography with dionosil (aqueous) preceded the use of dionosil oily.

The histologic appearance of the lower lobectomy specimen in the present case was quite different from that described by Holden and Cowdell. Granulomata were numerous and within some of them macrophages and giant cells did contain uniform droplets which stained brilliantly with Oil Red O. However, no large pools of fatty material were seen, nor were large drops seen within foreign body giant cells as in Brody's³ illustrations from a case of lipiodol granuloma.

The presence of a very small amount of carboxymethylcellulose in a few areas was suggested by the tartaric acid-thionine and PAS stains, but in our material neither stain was thought to show definitely the presence of carboxymethylcellulose. Certainly, most of the granulomata did not contain PAS or Feyrter-positive material as did the lesions described by authors studying carboxymethylcellulose in other bronchographic media.^{1,10,11}

Thus, the granulomatous lesions present in this case are dissimilar to the foreign body reactions after bronchography described by other authors. It seems more reasonable to interpret the present findings as the pathologic manifestation of a hypersensitivity reaction to some component common to both bronchographic media, namely, the organic iodide propyliodone.

As noted in the histologic description above, the greater part of the stainable lipid is present within macrophages in alveoli or interstitial tissue and not in granulomata. The presence of the small amount of fat within giant cells indicates that the lipid was introduced into the lung at the time the granulomatous response began. The small amount, however, precludes consideration of it as an etiologic factor by itself. Rather, it is thought to

represent the vehicle, arachis oil, in which the organic iodide was administered for the second bronchography.

In 1947, Goddard⁶ pointed out that the granuloma represents "a characteristic 'qualitative' change in the focal anaphylactic inflammation," and more recently Goldgraber and Kirsner⁷ summarized their work and that of others by stating that in experimental animals "the granuloma, with or without giant cells, though not pathognomonic, is highly characteristic of the hypersensitive state."

This aggregation of macrophages which comprises the granuloma is considered by many to represent the morphologic counterpart of antigen removal, and in sensitized experimental animals a pronounced granulomatous response has been demonstrated within a few hours after injection of the second or shocking dose of antigen.⁷ Thus, if the patient had been sensitized by dionosil (aqueous), the interval of four days between the instillation of dionosil oily and the lower lobectomy would undoubtedly have been long enough to permit the development of the florid histologic picture seen in the tissue sections.

From a practical standpoint it is suggested that granulomatous hypersensitivity reaction be added to the list of differential diagnoses when pulmonary nodularity is either seen on roentgenograms or encountered at operation following repeated bronchography. How long such nodularity may persist is unknown, but in the course of a hypersensitivity response there is typically a progressive change in the character of the exudate and an increase in fibroblastic proliferation, both of which might be expected to produce alterations in the roentgenologic or the gross appearance of the lesions over the course of several days.

SUMMARY

A pronounced granulomatous reaction in the lung was present when lobectomy was

performed for nontuberculous bronchiectasis four days after the second of 2 bronchographies. Dionosil (aqueous) in the first instance and dionosil oily in the second were the radiopaque agents used. The histologic characteristics of the tissue response were strongly suggestive of a hypersensitivity reaction.

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BRONCHIOLAR BEHAVIOR IN PULMONARY EMPHYSEMA AND IN BRONCHIECTASIS*

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THE behavior of the human bronchioles is a fascinating subject for investigation, in either the normal or the diseased state.

In 1938, Ellis⁷ studied the behavior of the larger bronchi in dogs by means of a tube and a balloon. He noted that a constant tone is present in the bronchus, with rhythmic changes during expiration. He believed the respiratory changes to be of passive origin. Di Rienzo,⁵ in 1949, described his observations of the bronchioles when they were visualized using opaque oils. He also reported a localized "functional stenosis" which developed on cough, shouting and sometimes in asthma and bronchitis.⁶

The purpose of this paper is to describe some of the points of interest which we have found in our investigations of the respiratory tree. The observations made of normal, emphysematous and bronchiectatic bronchioles will be discussed.

METHOD AND MATERIAL

A total of 54 patients was studied. They were prepared for bronchographic examination in a routine manner. All were fasted for six hours prior to the procedure. Pre-examination medication consisted of sodium phenobarbital, atropine and demerol, all given intramuscularly. A 0.5 per cent pontocaine containing adrenalin in a 1 to 1,000 solution, one drop per 20 cc., was used as a local anesthetic. The amount of pontocaine solution varied from 5 to 10 cc. All studies were carried out on conscious and co-operative patients. The medium employed was dionosil oily.*

* Obtained from Glaxa Laboratories Ltd., Greenfield, Middlesex, England through the Picker X-Ray Corporation, White Plains, New York.

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Routine bronchography was done on all of the patients. Some patients were studied with a rapid film changing apparatus during deep respiration. Others had bronchograms made during deep inspiration, normal expiration and forced expiration.

The bronchograms were analyzed and observations were made as to the behavior of the bronchi and bronchioles in both normal and diseased conditions.

RESULTS

NORMAL BRONCHIOLES

This group consisted of 21 patients admitted for diagnostic procedures. The chief complaint of most of these patients was asymptomatic hemoptysis.

The normal bronchioles had rather smooth parallel walls which remained parallel throughout the normal respiratory cycle. If expiration was forced, however, irregularity of the walls developed with tapering of the distal bronchioles. The change in caliber of the bronchioles in the normal respiratory cycle was slight, usually with only a 10-20 per cent decrease in size during normal expiration. On forced expiration, a further decrease in the caliber was noted—as much as 30 per cent on occasion. These changes (Fig. 1, *A*, *B* and *C*) were found primarily in the third through the sixth divisions of bronchioles.

It should be emphasized that the bronchioles distal to the sixth division showed little change in size or contour and that the larger bronchioles, when they were filled with contrast medium, showed very little change in caliber or contour during respiration.

BRONCHIECTASIS

This group consisted of 13 patients, all

of whom had histories of cough productive of purulent sputum. The extent of the disease varied from slight lobular involvement to marked generalized involvement.

The bronchioles affected by the bronchiectatic process showed a rather marked change in caliber during the normal respiratory cycle (Fig. 2, *A* and *B*), being larger than normal at both inspiration and expiration, and the percentage change was much greater than that found in the normal patient in corresponding respiratory phases. At forced expiration (Fig. 2*C*),

there was a further decrease in the size of the involved tubules. Here again, the change in size was not seen when the contrast medium filled the bronchioles, but only when an air contrast study was accomplished.

The bronchioles in the uninvolved portions of the lung appeared to function normally. A shift in position of the bronchioles was noted in those cases of bronchiectasis where compensatory emphysema had developed due to loss of neighboring lung volume.

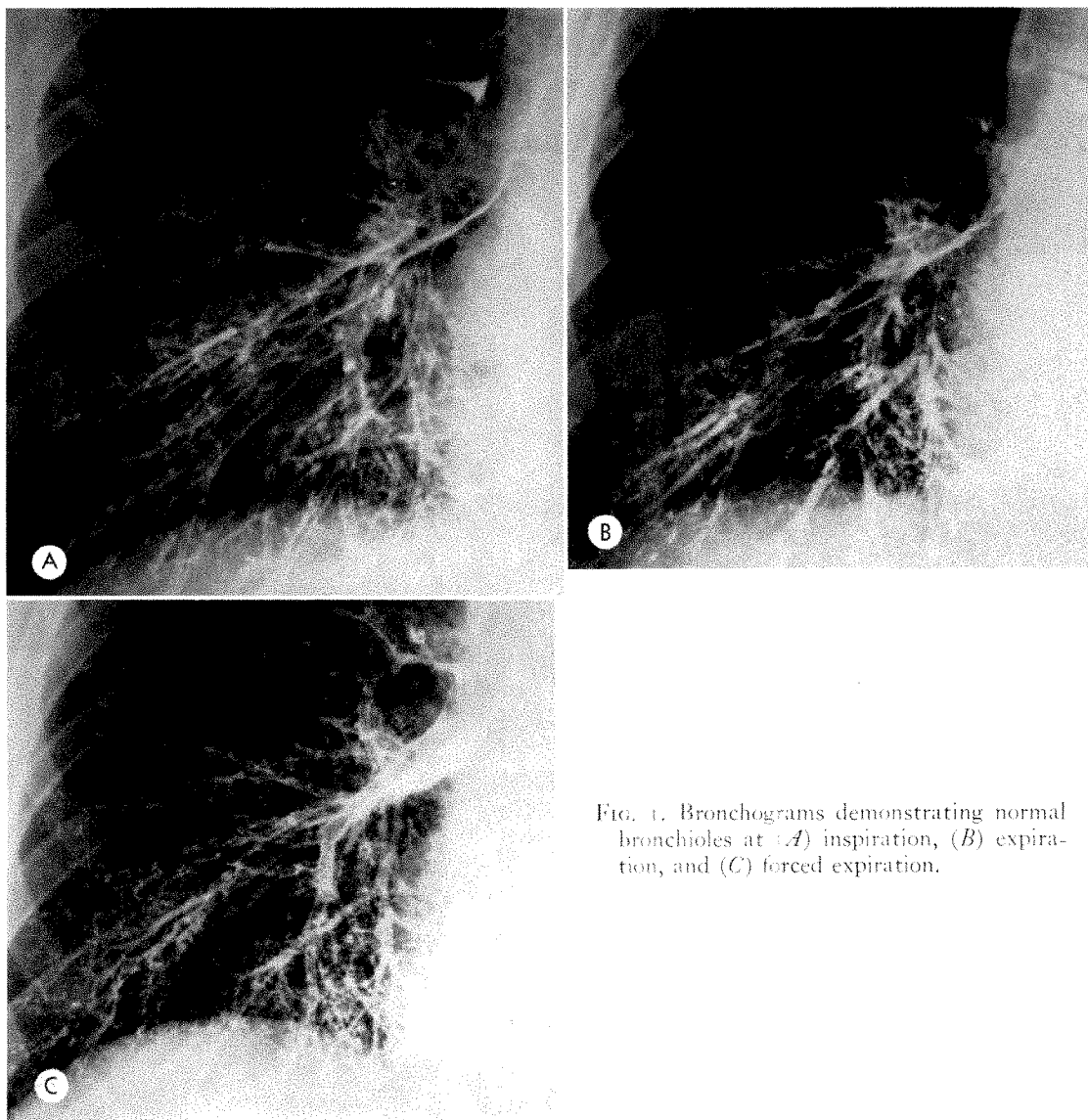


FIG. 1. Bronchograms demonstrating normal bronchioles at (*A*) inspiration, (*B*) expiration, and (*C*) forced expiration.

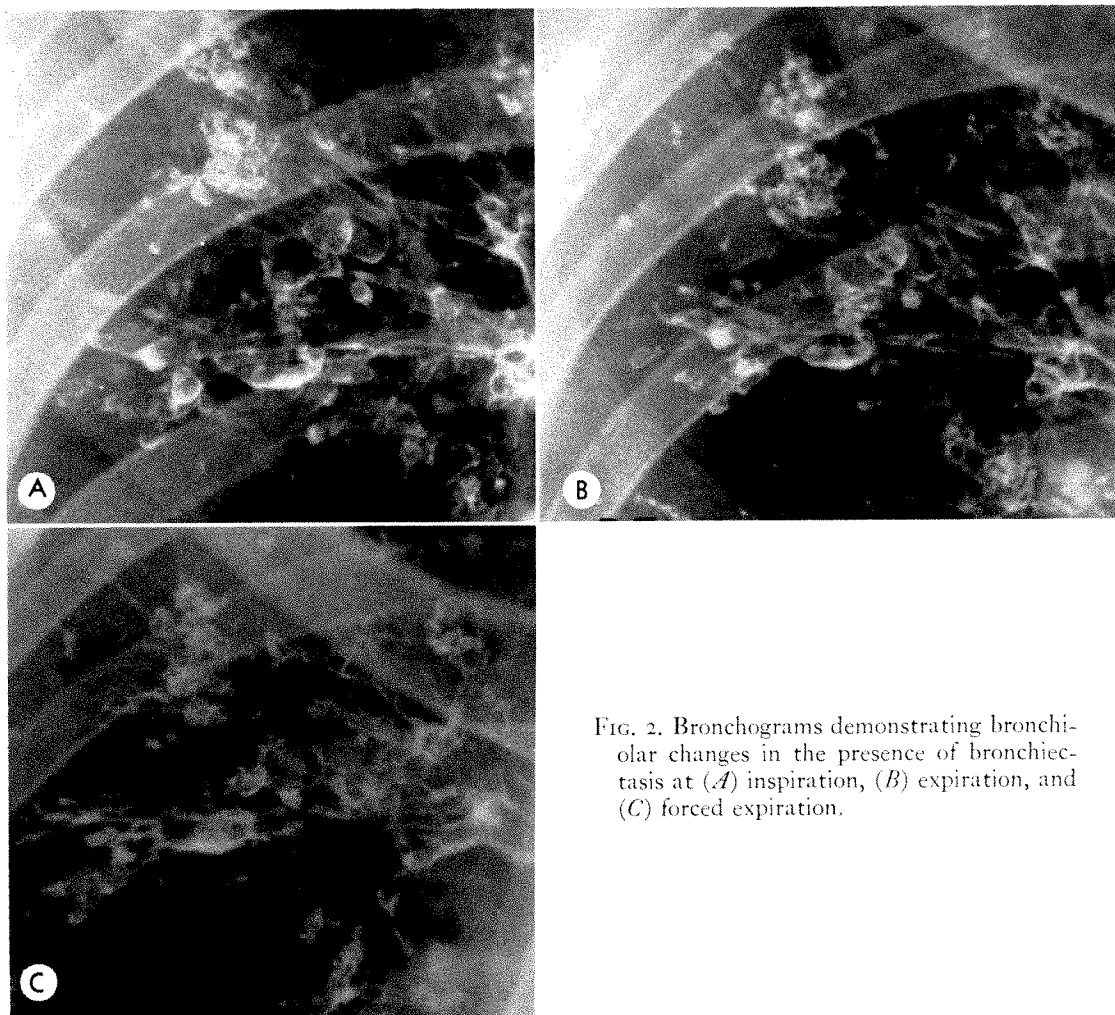


FIG. 2. Bronchograms demonstrating bronchiolar changes in the presence of bronchiectasis at (A) inspiration, (B) expiration, and (C) forced expiration.

PRIMARY EMPHYSEMA

A group of 12 cases with generalized primary idiopathic emphysema was studied. The changes noted in these patients were the most striking of any of the groups.

On inspiration, the bronchioles of the second through the sixth division appeared to be larger than normal. The walls, rather than being parallel, appeared to bulge somewhat between divisions. As expiration began, there was a rather rapid decrease in caliber with the diameter of some of the bronchioles being markedly reduced at the end of a normal expiration. When forced expiration was carried out, there was a further decrease in size, although percentage wise this was not as

marked as in the earlier phase of expiration.

The change in contour of the bronchioles is also worthy of note. As described above, at inspiration the bronchioles demonstrated a lobulated or interbifurcated bulge; however, at either normal or forced expiration a concavity was found to be present where a convexity previously had existed. This, as well as the marked change in caliber of the bronchioles during normal respiration, is demonstrated in Figure 3, A and B.

There were 3 cases in which these phenomena seemed to be localized. In 2 of them, the lingula was involved and in 1 the posterior basilar segment on the right. In all 3, however, the remaining bronchioles behaved normally.

COMPENSATORY EMPHYSEMA

A group of 7 cases of compensatory emphysema was studied. All represented an emphysema due to a decrease in the volume of adjacent lung tissue. The change in the caliber or contour of the bronchioles was not like that observed in primary emphysema but was well within the normal range. There was, however, a change in position seen in some of these cases which appeared to be more than that in the normal.

MISCELLANEOUS CONDITIONS

The remaining 7 patients included 2 cases of recent trauma, 1 each of asthma, bronchogenic carcinoma, subsiding acute bronchitis, pulmonary cavitation (pyogenic), and cystic disease—not a sufficient number of cases to evaluate them with any degree of certainty.

DISCUSSION

The behavior of the normal human bron-

chiole during inspiration and expiration is probably a result of the interaction of intrinsic and extrinsic forces. The intrinsic force might be defined as the tendency of the bronchiolar wall to resist changes in size (either a decrease or an increase), and the external forces as those outside the bronchiolar wall which tend to change the size of the bronchioles. These latter could include pressure from expanding adjacent alveoli, which would be conducive to collapse of the bronchioles, and traction produced by the tissues of the expanding lung, which would have the effect of enlarging the bronchioles.

If these assumptions are correct, one might expect an imbalance of these forces to manifest itself in abnormalities of behavior of the bronchioles during respiration. We believe this to be the case in bronchiectasis and primary emphysema.

As noted above, the bronchiectatic bronchiole is larger at both inspiration and expiration than is the normal bronchiole of

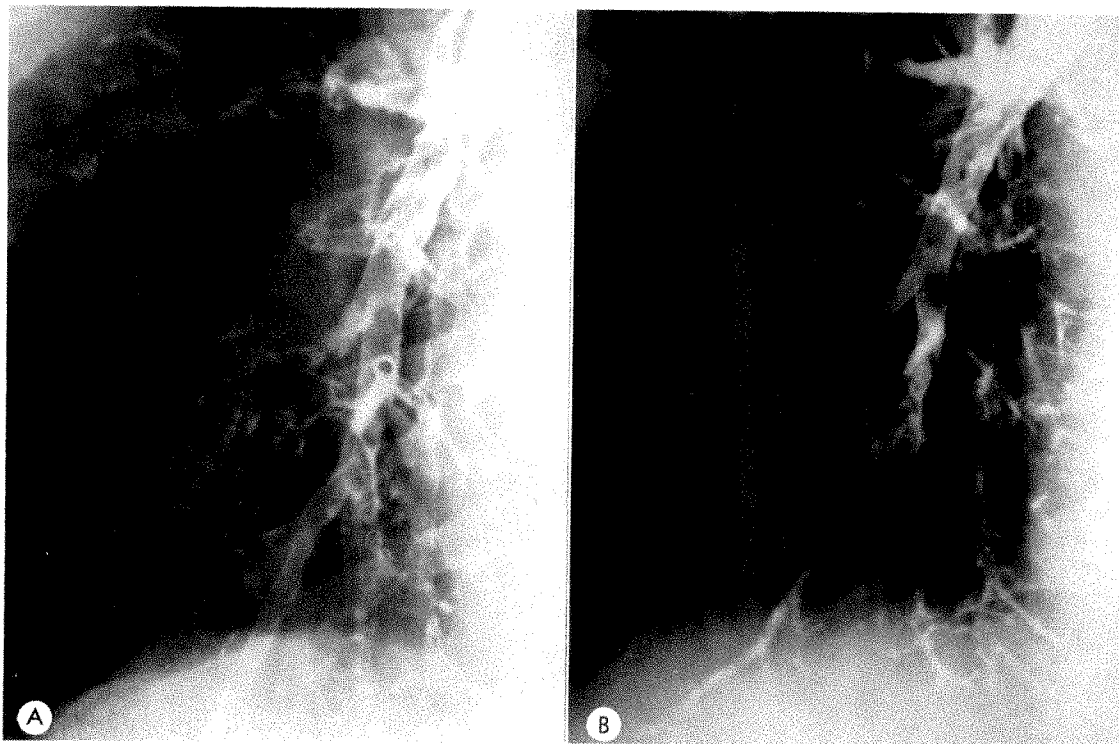


FIG. 3. Bronchograms demonstrating bronchiolar changes in the presence of primary emphysema at (A) inspiration, and (B) expiration.

a similar division. The percentage decrease at expiration, however, is much greater than normal. The lung tissue surrounding the involved bronchioles is decreased in elasticity and is contracted by the chronic inflammatory process. This produces a loss of lung volume as well as some rigidity of alveoli of the involved bronchiole. These effects, in addition to a loss of bronchiolar wall structural tissue, might be enough to counteract the lung rigidity and cause a decrease in size. There are undoubtedly other factors which determine the behavior of the bronchioles in this disease and perhaps further study will reveal these and furnish a fuller explanation.

The bronchioles in primary emphysema are much larger than normal at inspiration and smaller than normal at expiration. These changes were suspected by Hoover¹⁰ in 1913. Although reports in the literature^{1-3,12} indicate that a loss of lung tissue elasticity is the fundamental change in primary pulmonary emphysema, it is difficult to explain the observations of increased size of the bronchioles at inspiration in the presence of this loss of elasticity. The possibility of traction exerted on the walls of the bronchioles by the inelastic lung tissue exists; however, it seems unlikely that this would offer a satisfactory explanation in view of the decreased percentage of change in the total lung volume between inspiration and expiration.¹¹ This same factor complicates the analysis of bronchiolar behavior in compensatory emphysema, where also there is a stretching of the lung tissue. A loss of the intrinsic ability of the bronchiole to resist change, *i.e.*, a loss of bronchiolar rigidity, might explain the findings in primary emphysema, as has been described by several investigators in the past.^{8,9,13}

In the expiratory phase the pressure exerted by the alveoli on neighboring lung tissue is increased.^{4,9} This may be due to the relative obstruction existing in the bronchioles preventing the normal emptying of the alveoli during expiration. The

obstruction, manifested as a valve-like collapse of these bronchioles, may again be due to a loss of the intrinsic rigidity of the bronchioles or to a loss of support from the surrounding lung tissue. This might explain the behavior of the bronchioles in primary emphysema during expiration.

In summary, it would seem that the major defect in primary emphysema might be the loss of rigidity or integrity of the bronchiolar walls, with other changes being secondary to this. A defect such as this offers a logical explanation for the changes observed on these studies.

The failure of the bronchioles, when they are filled with contrast medium, to change in size with the respiratory cycle probably can be accounted for by the relative inertia of the bronchiolar walls due to the hydrostatic pressure and capillary traction of the viscous medium.

Regardless of the mechanism responsible for the behavior of these portions of the respiratory system, it would seem that much could be learned of respiratory pathophysiology by observations of the bronchioles at the time of bronchographic study. We do not believe that fluoroscopic observation alone is sufficient for evaluation. A simple procedure such as bronchography after normal expiration and forced expiration may contribute much to the radiologist's ability to evaluate the bronchiolar tree.

SUMMARY

Bronchographic examinations were made during normal inspiration, normal expiration and forced expiration. It was found that normal bronchioles decrease slightly in size during normal expiration and to a much greater extent during forced expiration. It was also found that the bronchiectatic bronchioles and bronchioles of patients with primary emphysema appear larger during inspiration than the normal bronchioles; however, they decrease markedly in size during normal expiration, and a further decrease in size is noted during

forced expiration. The possible mechanism of these changes is discussed.

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PRIMARY PULMONARY CRYPTOCOCCOSIS

CASE REPORT

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CRYPTOCOCCUS neoformans (Torula histolytica) is a saprophytic yeast found in the soil and in pigeon excreta, and is pathogenic for man, with a predilection for the central nervous system. The skin, mucous membranes, bones and lungs may also be involved by the disseminated form of cryptococcosis, but less commonly pulmonary cryptococcosis may be seen without central nervous system involvement, and it is this form of the disease with which this report is concerned.

REPORT OF A CASE

J. W., a thirty-two year old white married U. S. Coastguardsman, was admitted to the U. S. Public Health Service Hospital, Chicago, Illinois, on October 7, 1960 with complaints of pain in the right chest of about one week's duration. He thought he had "pulled a muscle" and later stated that the pain was aggravated by rotatory motion of the right shoulder. There had been a 15 pound weight loss during the preceding month, anorexia and night sweats for about six weeks. A chronic cough, which was attributed to cigarette smoking, had been present for about one year. Immediately prior to admission a chest roentgenogram had been obtained at the U. S. Public Health Service Out-Patient Clinic, St. Louis, Missouri, where the patient had initially sought medical advice, and it had been reported as demonstrating "a pneumonitis."

The patient had been in the U. S. Coast Guard for the past fifteen years, the last eight of which had been spent in the mid-West. From 1953 to 1958 he had been stationed in Paris, Tennessee, and he recalled that during this period he had been exposed to large amounts of bird excreta, at least some of which may have been from pigeons.

He had undergone an appendectomy in 1943 and a pilonidal cystectomy in 1953. The system

review during the week prior to admission disclosed mild shortness of breath.

Physical Examination. The pulse was 80, temperature 98.6° F., respirations 20 and blood pressure 128/80. The only positive findings were some rales over the right posterior chest, some scaling of the skin between the toes and tattooed upper extremities.

Laboratory Data. The admission hemoglobin was 14.8 gm. per cent, hematocrit 46.5 per cent and white blood cell count 10,750 with 57 neutrophils, 1 band and 42 lymphocytes. The corrected sedimentation rate was 25 mm./hr. The urinalysis was normal and the serology nonreactive. No significant changes occurred in these values except for a slight rise in the sedimentation rate with a subsequent decline to normal values. Initial sputum cultures produced a heavy growth of *Pseudomonas* and a few beta *Streptococci*. Febrile and cold agglutinins were negative as were serum titers for blastomycosis, coccidioidomycosis and histoplasmosis (antigens 1 and 2). Skin tests for these diseases and a first strength purified protein derivative (PPD) for tuberculosis were negative, but a second strength PPD was questionably positive. Papanicolaou smear and cell block examination of the sputum revealed no tumor cells. Smear and culture of the sputum for acid-fast bacilli were negative. Sputum cultures for fungi showed no growth until a week following thoracotomy when a fungus suspected as being *Cryptococcus* was found. It was not until six weeks following surgery that the organism cultured from the surgical specimen was definitely identified as *Cryptococcus neoformans*.

Roentgen Findings. Roentgenograms of the chest in posterior-anterior and right lateral projection (Fig. 1, A and B) revealed homogeneous infiltration of the right upper and mid-lung fields. Localization of the densities on the lateral roentgenogram was less definite but a localized area of increased density in the pos-

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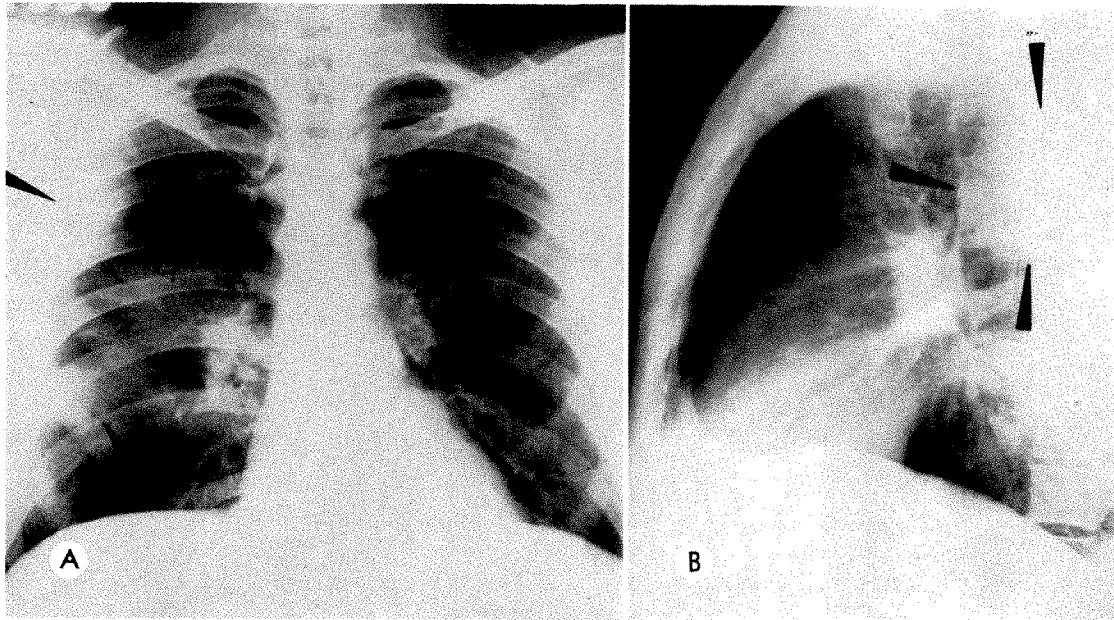


FIG. 1. (A) Posteroanterior chest roentgenogram one week prior to surgery. Homogeneous infiltration of the right upper and mid-lung fields is seen (arrows). The uppermost density shows a sharp medial margin. The mid-lung field lesions are less-well defined. (B) Right lateral chest roentgenogram obtained at the same time. Only the upper lung field density (arrows) could be localized. Its anterior margin is smooth. There is slight prominence of the markings in the posterior basilar region.

terosuperior region was felt to be present, most likely involving the posterior segment of the upper lobe. In posteroanterior views the more superiorly and laterally situated density in the upper lung field exhibited a rather distinct medial margin. Several repeat chest examinations showed little, if any, significant change. Anteroposterior laminagrams were obtained and demonstrated the uppermost lesion best at levels 6 through 12 cm. (Fig. 2). The mid-lung field lesions were poorly outlined by laminagraphy, although some areas of increased density were identified. No cavities or calcifications were present roentgenographically.

Although it was initially felt that the infiltration was inflammatory in nature, the unchanging appearance over about a month and the discrete appearance of at least the upper lesion raised the question of a possible unusual neoplasm. An intrapleural process, rather than intraparenchymal, was considered, but a diagnostic pneumothorax was not performed. Roentgenograms of the hands, wrists, feet and ankles did not demonstrate any evidence of hypertrophic pulmonary osteoarthropathy.

Hospital Course. In spite of relatively few and minor symptoms, which, in fact, seemed to

abate shortly after admission, the patient received antibiotic therapy consisting of tetracycline, penicillin, streptomycin and sulfasoxazole. The roentgen appearance of the chest, as indicated above, remained unchanged. On November 10, 1960 a right exploratory thoracotomy was performed and a "tumor mass" was described, involving the right upper and lower lobes, adherent to the pleura in the upper lobe region. A right pneumonectomy and mediastinal lymphadenectomy were done, the adherent upper lobe lesion necessitating an extrapleural dissection in that area. The procedure was well tolerated and the postoperative course was uneventful except for a transient, mild penicillin reaction.

The patient was discharged from the hospital on November 23, 1960 and followed in the outpatient department. He was re-admitted to the hospital on January 13, 1961 for further evaluation and therapy following positive identification of the etiologic agent from the surgical specimen. At the time of the second admission, the thoracotomy wound was well-healed and slightly painful. Occasional nonproductive cough and "2-flight dyspnea" were described. Physical examination revealed chest findings

due to the pneumonectomy but no other significant abnormality, and the usual laboratory studies were normal. Lumbar puncture produced clear, colorless cerebrospinal fluid containing three polymorphonuclear leukocytes and one lymphocyte per cubic millimeter. Spinal fluid glucose was 43.1 mg. per cent, protein 11.8 mg. per cent and chlorides 124 mEq./l. There was no growth on culture. Chest roentgenograms showed evidence of a right pneumonectomy with moderate mediastinal shift and a clear left lung field.

Pathology. The right lung weighed 520 gm. and presented three smooth bulges (Fig. 3A), the largest of which occupied the superior segment of the lower lobe and measured $8.5 \times 7.0 \times 2.5$ cm. The other lesions were smaller and occupied the posterior segment of the upper lobe and the area near the junction of the posterior and anterior segments of the upper lobe. The middle lobe was grossly disease-free. The cut surfaces of the masses (Fig. 3B) were pale tan and contained scattered, ill-defined, light yellow opaque areas of necrosis up to 1.5 cm. in



FIG. 2. Anteroposterior chest laminagram at the 8 cm. level. The smooth-margined density merges with the chest wall (top arrow). The mid-lung field densities were not well-defined (lower arrows).

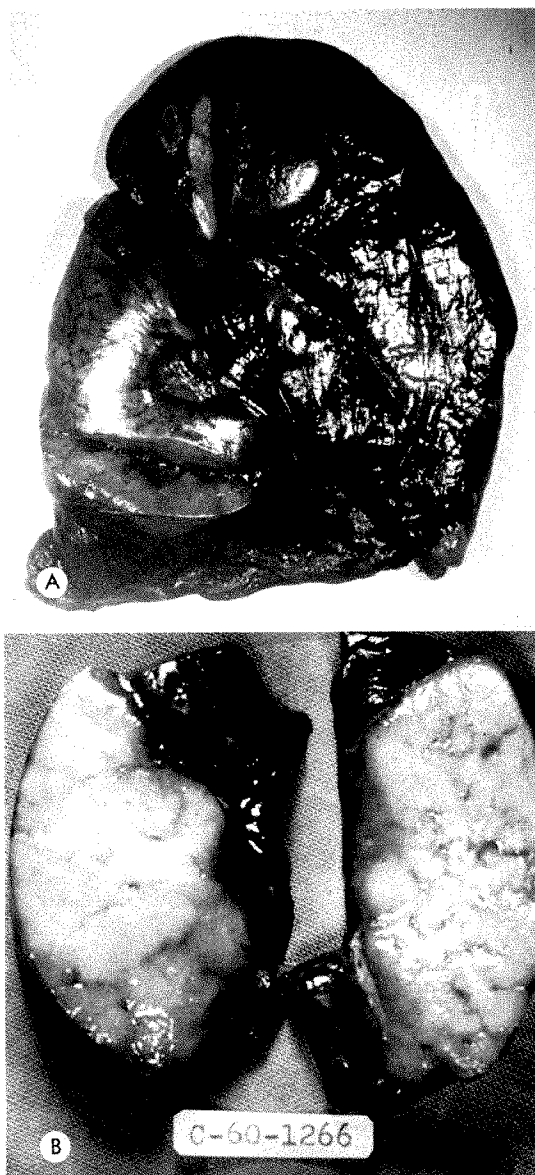


FIG. 3. (A) Entire right lung viewed from its lateral aspect. The bulging tumor-like masses had been incised following removal, disclosing firm, tan tissue suggesting neoplasm. (B) Transected lesion from the posterior segment of the upper lobe. The similarity to neoplastic tissue is apparent.

diameter. At least seven lymph nodes measuring up to 1.5 cm. in diameter were found.

Microscopically, the less-involved lung parenchyma displayed thickened alveolar septa with lymphocytic and mild polymorphonuclear leukocytic infiltration. The alveoli contained histiocytes and occasional multinucleated giant cells. The lung lesions *per se* were granulo-

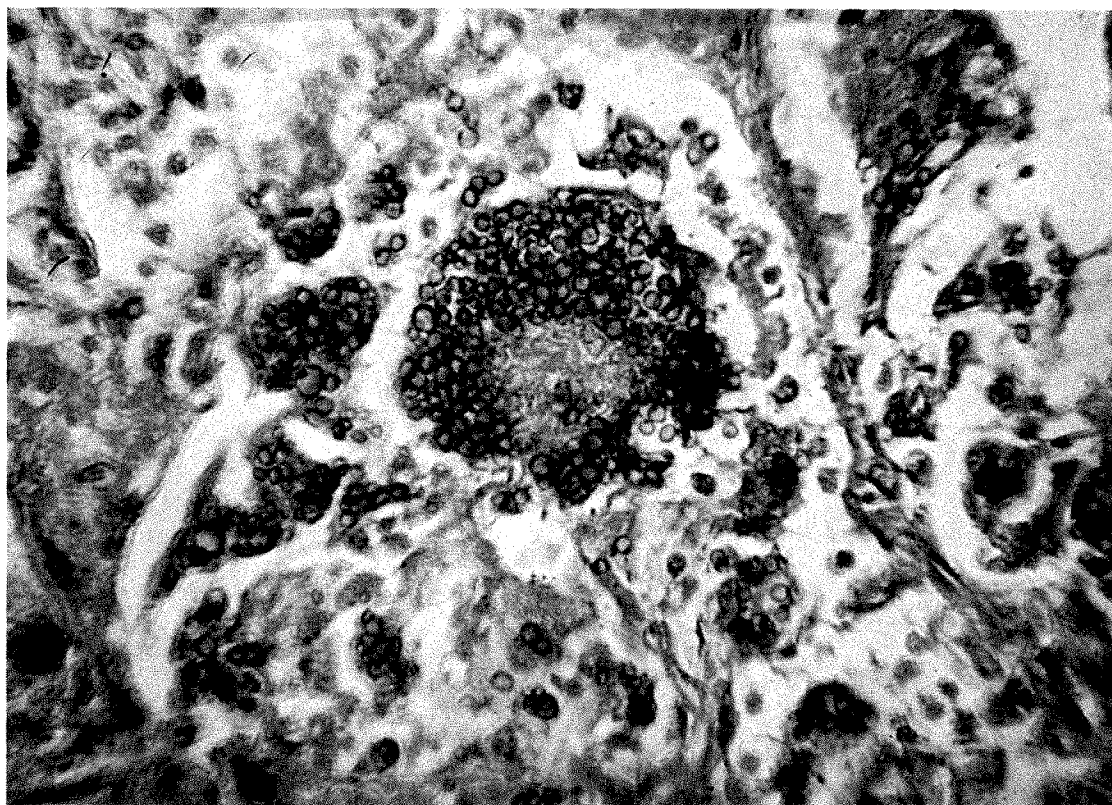


FIG. 4. Microscopic section from one of the parenchymal lung lesions stained with Gridley's fungus stain. In the center is a large giant cell containing numerous cryptococci. Several "satellite" clusters of organisms are noted, probably situated within histiocytes, and there are fungus cells lying free within the alveolar spaces. The alveolar septa are thickened ($\times 430$).

matous, and some were necrotic with microscopic cavity formation. Cellular architecture was similar to that described above with the additional finding of numerous vacuoles within the histiocytes and giant cells. The vacuoles, upon Gridley's and Gömöri's fungus staining, were found to represent individual and clustered organisms averaging 7 to 10 μ in size (Fig. 4). Some of the lymph nodes were the site of granulomatous reaction similar to that described in the lung lesions (Fig. 5) and special staining also demonstrated the presence of the yeast organisms within these granulomata. The initial pathologic diagnosis was "confluent mycotic granulomata with cavitation in the right upper and lower pulmonary lobes with involvement of peribronchial lymph nodes."

Cultures of the surgical specimen and the fungal cultures of the sputum were sent to the Communicable Disease Center, Atlanta, Georgia, and to The Armed Forces Institute of Pathology. On December 23, 1960 both

agencies identified the organism as *Cryptococcus neoformans*.

DISCUSSION

Quite commonly, the signs and symptoms of pulmonary cryptococcosis are minimal or even absent altogether. Cough, scanty sputum, rare hemoptysis, low-grade fever, pleuritic chest pain and weight loss may occur, but it is not uncommon for the patient to be asymptomatic and the presence of pulmonary disease to be discovered on routine chest examination.³ Occasionally, mild symptoms call attention to the disease, as was true in our case.

The roentgen findings in pulmonary cryptococcosis vary considerably and are not characteristic of the disease.^{3,5} The most commonly observed pulmonary lesion, according to Littman,⁵ is a solitary, moder-

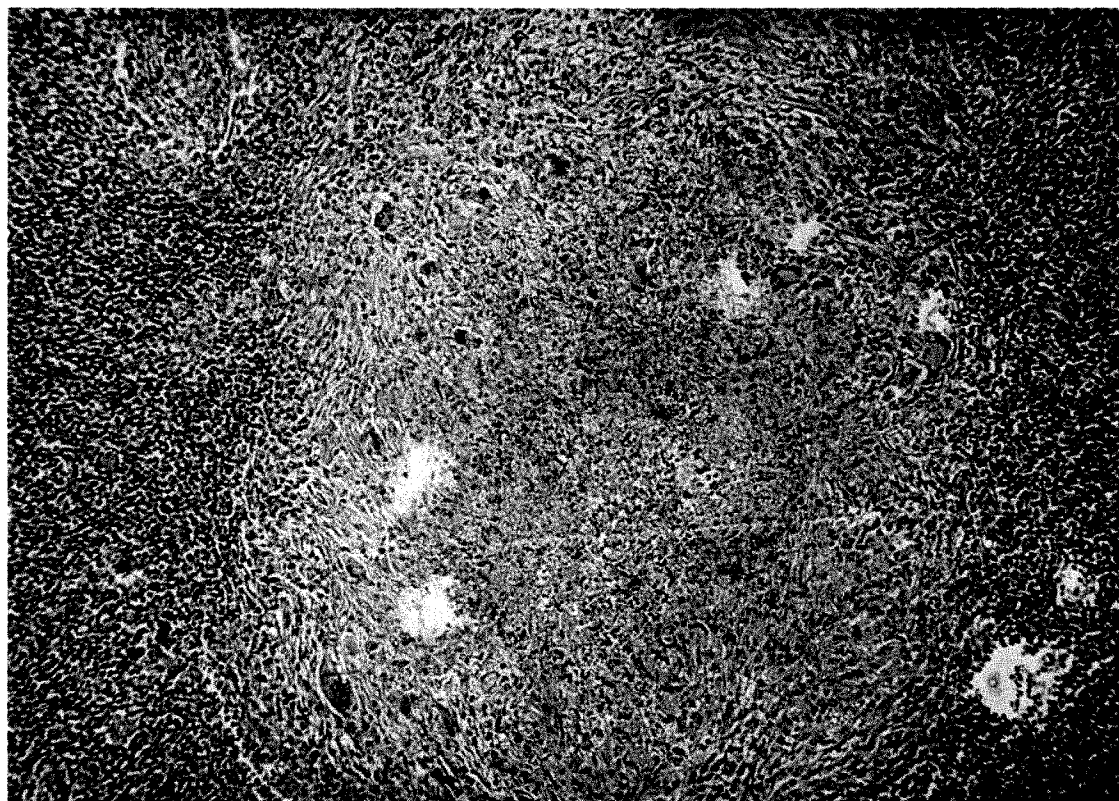


FIG. 5. Microscopic section from one of the peribronchial lymph nodes demonstrating a granulomatous reaction. There are giant cells visible, which, with special staining (not reproduced), were found to contain organisms as shown in Figure 4 ($\times 100$).

ately dense area of infiltration in the lower half of either lung field, varying in size from 2 to 7 cm. Greening and Menville² also emphasized the predilection of the infiltrates for the bases of the lungs, but, of 9 cases of torulosis with pulmonary involvement reported by Wolfe and Jacobson,⁸ 7 had upper lobe disease. Cavity formation and hilar lymphadenopathy are rarely demonstrated roentgenographically, although upon pathologic examination of the specimen in our case both cavities and lymph node granulomata were found. Diffuse, broad pneumonic infiltrations may occur and differential diagnosis is difficult. It includes such conditions as primary and metastatic carcinoma, sarcoidosis, chronic pulmonary tuberculosis, bronchiectasis, pneumoconiosis, hydatid cyst and other fungus diseases. "The possibility of pulmonary torulosis should be borne in mind

when there is a persistent asymptomatic parenchymal lesion which has inflammatory characteristics and which is resistant to diagnosis by ordinary laboratory procedure, especially if the patient is showing no evidence of a malignant neoplasm."³

The roentgen findings may often far exceed those expected in comparison to the rather mild clinical picture. Froio and Bailey¹ reported a case similar to our own in which the roentgen findings were interpreted as due to neoplasm and a right pneumonectomy was performed. This patient was well with no complaints five years and seven months following surgery. These authors suggest that the patient may be cured if the disease is local and can be diagnosed and removed before meningeal spread has occurred. Ratcliffe and Cook,⁷ who also described a case of primary pulmonary cryptococcosis, feel that a pa-

tient showing pulmonary involvement of a localized nature, in the absence of systemic spread, should be given the benefit of surgical removal of the involved lobe of the lung.

Since death may occur from one month to fifteen years later,⁸ the administration of an effective antifungal antibiotic is necessary, even where there has been apparent complete removal of the pulmonary lesions. Amphotericin B is effective in the treatment of cryptococcosis and our patient is now receiving prophylactic treatment. It is Littman's⁶ belief that in patients not covered by amphotericin B at the time of surgery, the incidence of cryptococcal meningitis is lower in those who undergo lobectomy or pneumonectomy, as opposed to those who undergo wedge resection. Postoperatively, he recommends a course of intravenously administered amphotericin B until at least 1,000 mg. has been given. For further details regarding the nature and use of this antifungal agent, as well as more information on the epidemiology, laboratory diagnosis and pathology of cryptococcosis, the reader is referred to original articles published by Littman.^{4,5}

SUMMARY

A case of primary pulmonary cryptococcosis is reported. Surgical resection of the involved lung was successfully per-

formed and there is no evidence of dissemination at the time of this writing. The patient is receiving prophylactic treatment with amphotericin B. The literature is briefly reviewed and the roentgen findings in pulmonary cryptococcosis are described.

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REGIONAL ROENTGEN MANIFESTATIONS OF HISTOPLASMOSIS*

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THE incidence of histoplasmosis in the general population of the United States has increased considerably in the past decade; the abundance of reports in the medical literature parallels the increase in the number of patients suffering from this lung condition once termed rare. These patients are frequently referred for roentgen studies so as to discover the origin of the varied and nonspecific complaints which accompany this disease. The radiologist may then uncover suspicious signs leading to the diagnosis of histoplasmosis, once he is acquainted with the roentgenographic manifestations produced in the body systems by the infection of *Histoplasma capsulatum*.

THORACIC HISTOPLASMOSIS

PULMONARY MANIFESTATIONS

Pulmonary involvement occurs in about 50 per cent of cases infected by *H. capsulatum* and presents itself as a wide variety of roentgen patterns. Four main groups of pulmonary lesions can be described without attempting to classify them: single, disseminated, chronic and healed.

The most common finding in early pulmonary involvement is the *single* pulmonic infiltrate. This is usually small, discrete and occurs at the peripheral lung zones as a soft, ill-defined patch of diminished aeration with no characteristic features (Fig. 1A). Unless the chest roentgenogram is obtained within the first two weeks from the onset of the disease, these infiltrates cannot be seen. In other cases, several fine radiating infiltrates are observed extending from the hilar areas into the mid-lung zones. These streaky infiltrations may become confluent into an extensive patch of

diminished aeration occupying a lobar segment and appearing in the roentgenograms as an area of consolidation (Fig. 1B). Nearly 40 per cent of cases with pulmonary parenchymatous disease show bilateral hilar lymphadenopathy. This may occur without pulmonary involvement as isolated hilar, mediastinal or paratracheal lymph node enlargement, which is hard to differentiate from that occurring in other inflammatory and neoplastic conditions (Fig. 1, C and D). The lung infiltrate with the associated hilar lymphadenopathy is considered to be similar to the primary complex of pulmonary tuberculosis.

The *disseminated* form of pulmonary involvement occurs in patients who are acutely ill, and is commonly seen in epidemic histoplasmosis.² It can be fatal, but many cases recover after a mild illness. The pea-sized, poorly circumscribed infiltrates can be seen scattered throughout both lung fields including the apices, peripheral lung zones and bases, sometimes superimposed on hilar lymphadenopathy or larger pulmonary infiltrates (Fig. 2A).

Multiple large nodular lesions have been reported but are uncommon.²⁶ Several clearly demarcated coin shaped lesions can be seen in these cases occupying any segment of the lungs and simulating metastatic pulmonary nodules (Fig. 2B). These lesions may become cavitory and appear as thin- or thick-walled cavities with air-fluid levels.²⁰

If the pulmonary involvement progresses, a large area of consolidation results with the formation of a tumor mass; breakdown of the lung parenchyma may occur producing a large thick-walled cavity surrounded by pneumonic consolidation and fibrotic

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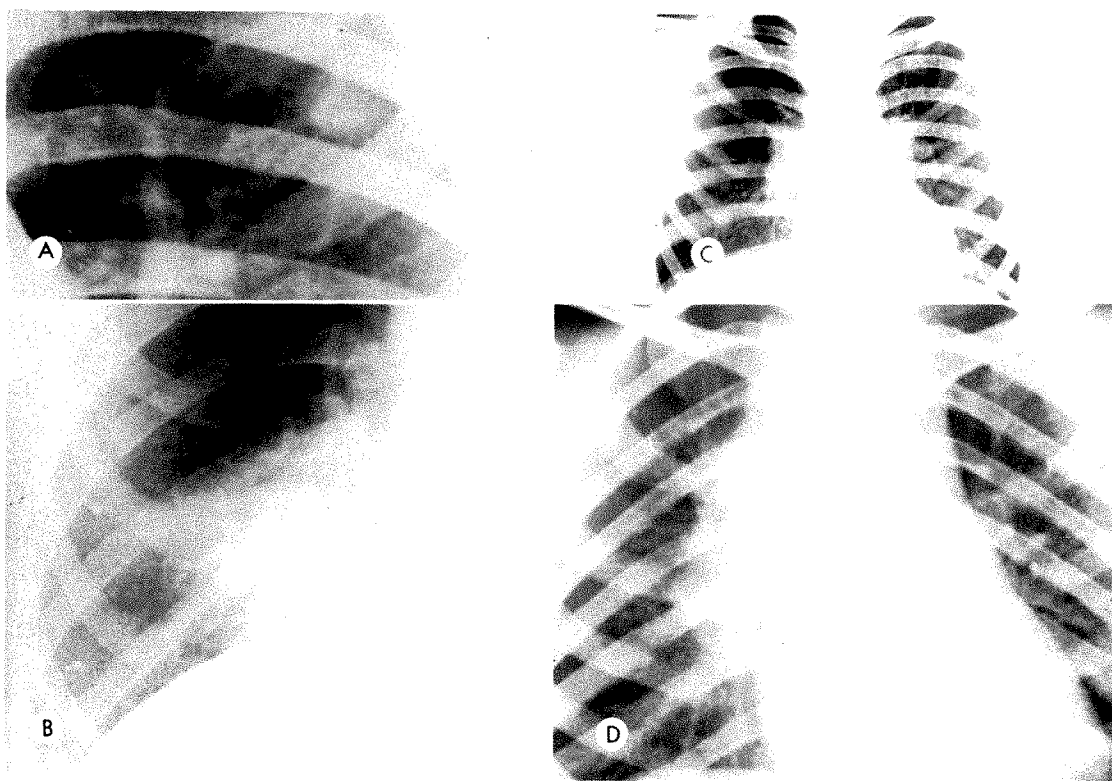


FIG. 1. (A) Isolated pulmonary infiltrate in a 4 year old child with positive complement fixation and histoplasmin skin tests. (B) Sixty-five year old patient with suspected findings of bronchogenic carcinoma which proved to be pulmonary consolidation due to histoplasmosis. (C and D) Hilar, mediastinal and paratracheal lymph node enlargement in two children with positive tests for histoplasmosis.

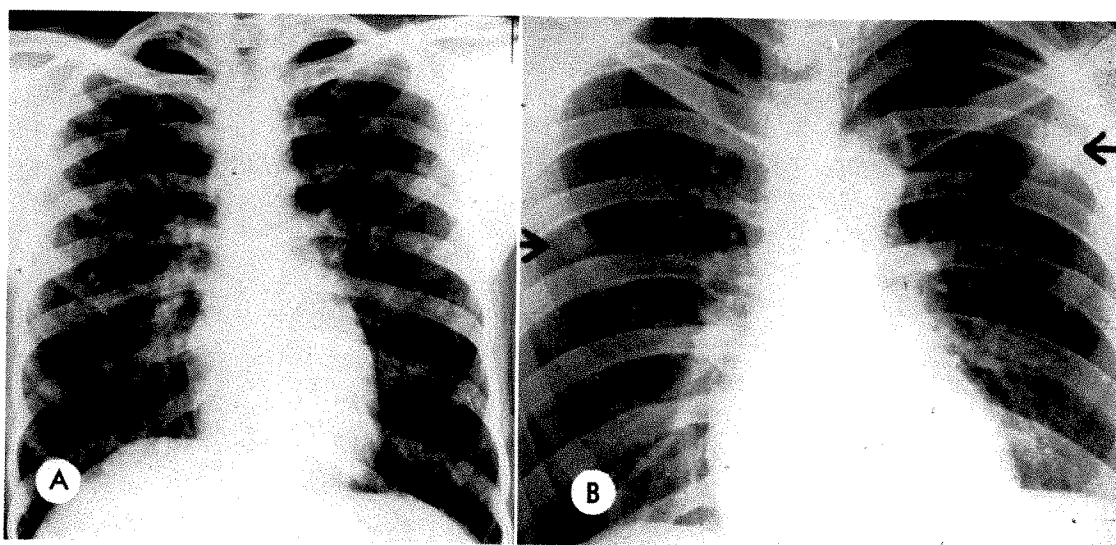


FIG. 2. (A) Miliary histoplasmosis in a 20 year old chronically ill patient. Workup for tuberculosis was negative. The patient recovered slowly. (B) Nodular histoplasmosis simulating metastatic disease of the lungs in a 27 year old patient with acute upper respiratory symptoms.

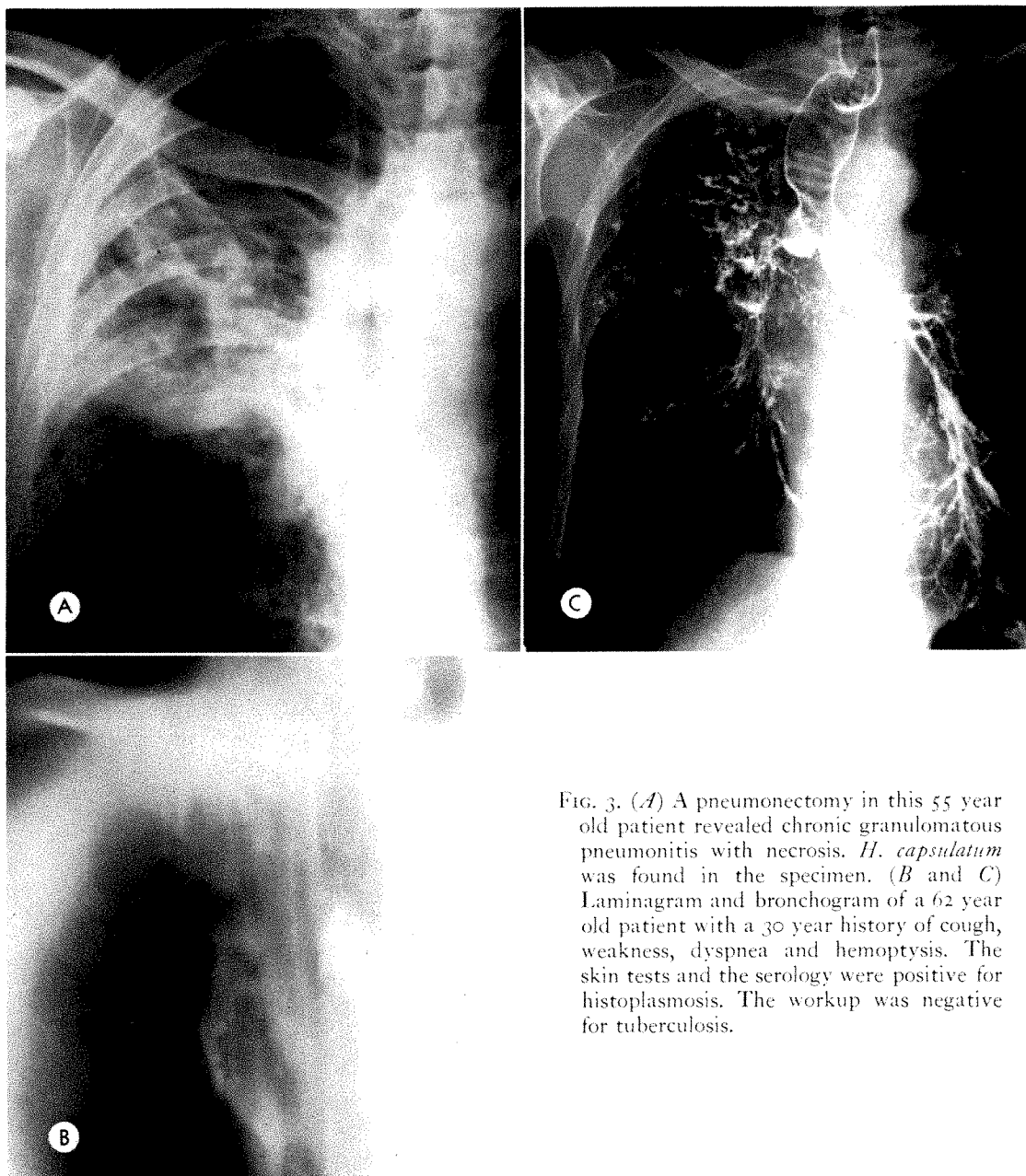


FIG. 3. (A) A pneumonectomy in this 55 year old patient revealed chronic granulomatous pneumonitis with necrosis. *H. capsulatum* was found in the specimen. (B and C) Laminagram and bronchogram of a 62 year old patient with a 30 year history of cough, weakness, dyspnea and hemoptysis. The skin tests and the serology were positive for histoplasmosis. The workup was negative for tuberculosis.

changes (Fig. 3A). This represents the *chronic* fibro-cavitary type of the disease which is hard to differentiate from neoplastic lesions and tuberculosis and sometimes coexisting with either one.

Pleural fluid is rarely seen in patients with thoracic histoplasmosis, even in the presence of extensive lung involvement.

Among the chronic types of pulmonary

histoplasmosis, bronchiectasis should be mentioned. This occurs more frequently than is suspected, and is either due to chronic lung disease with parenchymal changes or to obstruction of the bronchi.³ It is usually a nonreversible type of bronchiectasis, but sometimes it may regress to normal. It is possible that some cases of bronchiectasis of unknown origin

are due to histoplasmosis, but their etiology goes unsuspected when no special attempt is made to recover the fungi from pathologic specimens (Fig. 3, *B* and *C*).

Mediastinitis is another chronic type of thoracic histoplasmosis. There has been a recent increase in the number of reported cases dealing with granulomatous involvement of the mediastinum caused by *H. capsulatum*, and pathologists are now aware that this route of spread is not uncommon in intrathoracic histoplasmosis.^{14,27} Following the lymphatic channels, the organism may settle in the mediastinal structures forming a granuloma which may encroach upon the vascular trunks and produce obstruction.²¹ In other instances the changes are minimal and little or no manifestations occur. The roentgenograms may show widening of the superior mediastinum which may remain unchanged in progress studies. But the radiologist is usually faced with cases where the granuloma is producing vascular obstruction. Angiographic studies are then valuable in determining the site of the obstruction and its relationship with the mediastinal lesion (Fig. 4). It is possible that some reported cases of idiopathic mediastinitis have been produced by histoplasmosis.

The *healed* type of pulmonary histoplasmosis is the more commonly recognized

form of this disease. It is represented by intrathoracic calcifications which occur from two to five years after the initial infection. Four main types have been noted; single, hilar, miliary and calcified coin lesions. The single peripheral type of calcium deposit is similar to the Gohn focus of tuberculosis and it is commonly associated with hilar calcification; a "halo" may be seen around the focus of calcium. The hilar type is said to be typical when occurring in a "mulberry" or stippled fashion.³⁰ Miliary calcifications are similar to those produced by healed miliary tuberculosis and are seen in children and adults.

The calcified pulmonary coin lesions are usually called tuberculomas. With the increasing number of such calcified granulomas being removed surgically, it has been found that more than 50 per cent are due to histoplasmosis and only about 15 per cent can be considered as tuberculomas.⁹ Thus it is proper to call these pulmonary lesions histoplasmomas as suggested by Katz¹⁷ rather than call them tuberculomas as in the past. The different types of calcifications are shown in Figure 5, *A-D*.

Although the diagnostic value of the intrathoracic calcifications in histoplasmosis is minimized by their late appearance, there are cases where it is important to recognize them. In patients with hemoptysis or signs of bronchial obstruction, the presence of hilar calcifications can offer a clue to the diagnosis of bronchial obstruction due to large calcified lymph nodes or broncholithiasis produced by histoplasmosis (Fig. 6).

CARDIOVASCULAR MANIFESTATIONS

Several cases of calcified pericarditis have been reported recently occurring in patients with histoplasmosis.^{5,16,22} The association of pericardial calcification or effusion with a strong sensitivity for histoplasmin and a negative tuberculin test suggests that *H. capsulatum* can cause pericarditis. Two such cases were recently studied: one with extensive pericardial effusion where *H. capsulatum* was recovered from the pericardial fluid, and the other

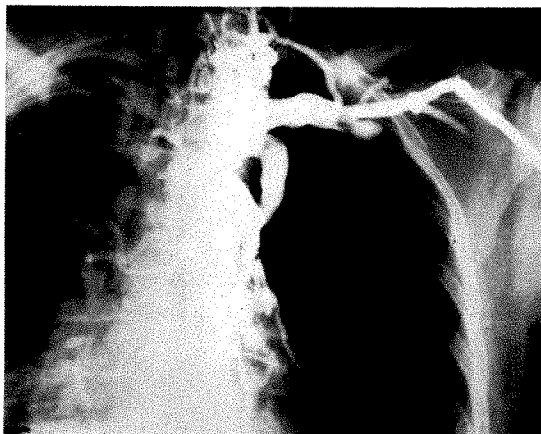


FIG. 4. Forty-six year old woman with chronic lung disease. A calcified granuloma due to histoplasmosis was found obstructing the superior vena cava. This was demonstrated preoperatively by angiocardiology.

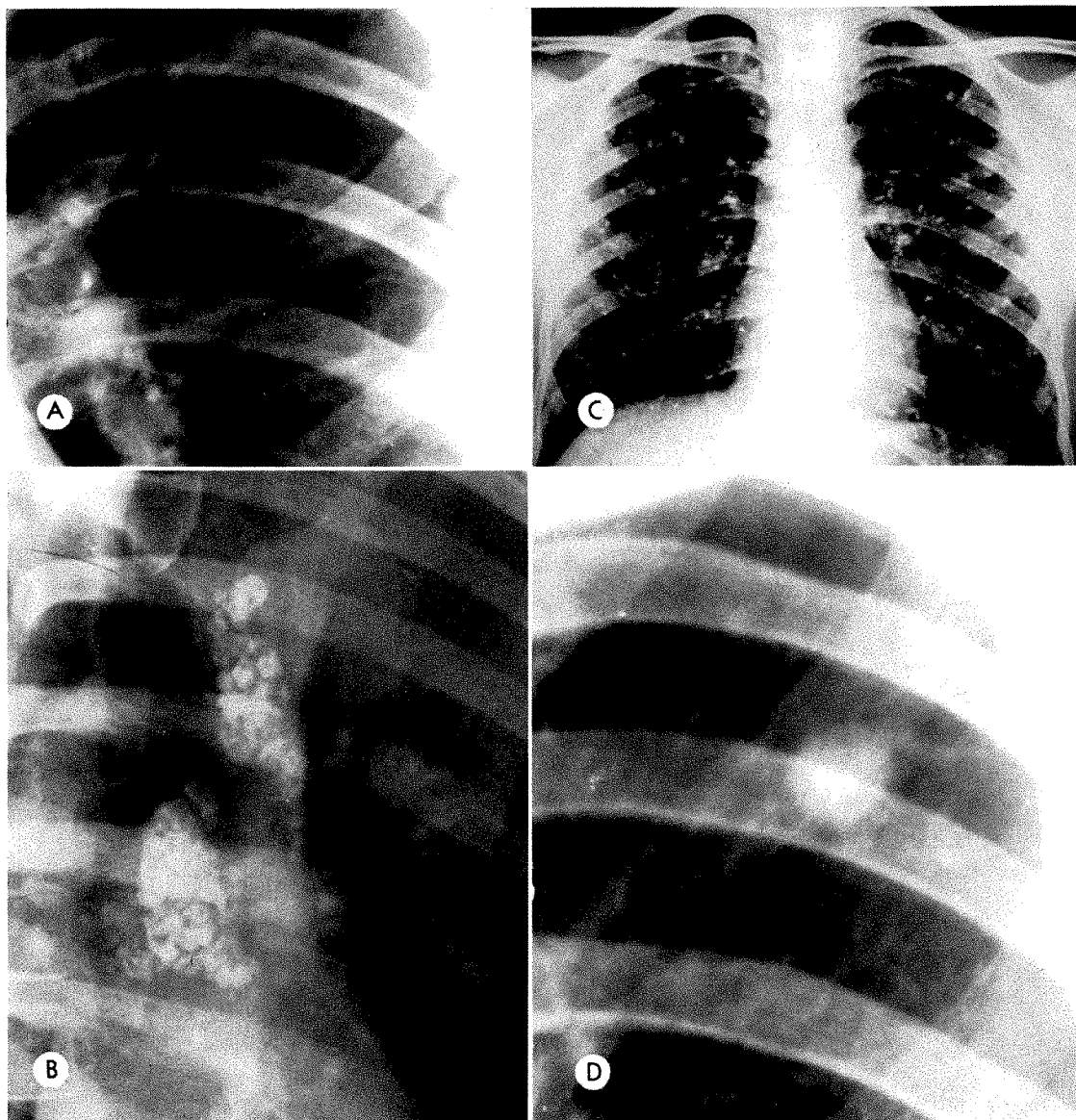


FIG. 5. (A, B, C and D) Single, "mulberry," miliary, and nodular types of calcifications in patients with old healed pulmonary histoplasmosis.

with severe calcification of the pericardium (Fig. 7). It is possible that histoplasmosis is the cause of some of the so-called cases of idiopathic pericarditis. A careful study of the fluid or surgical specimens obtained from these patients should be of value. Infective endocarditis due to histoplasmosis has also been reported¹¹ but no abnormal roentgenographic manifestations can be detected in such cases. In patients having pericardial effusion or calcified pericarditis, the roentgenographic findings are similar

to those occurring in cases without histoplasmosis.

ABDOMINAL HISTOPLASMOSIS

Almost every organ has been reported to be involved in cases of abdominal histoplasmosis. The liver, spleen and adrenals appear to be more vulnerable to this fungus infection. In disseminated histoplasmosis the adrenal glands are almost always involved. Adrenal insufficiency may then ensue due to massive destruction of the

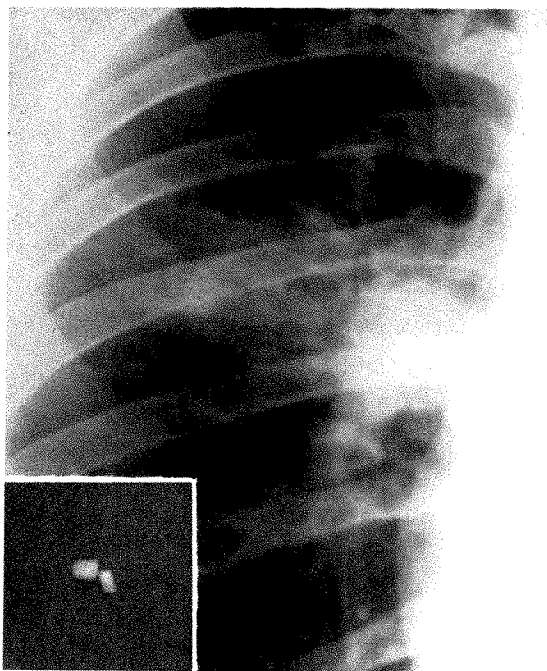


Fig. 6. This 23 year old medical student coughed up bits of calcified material (insert) the night before his admission. The consolidation noted in this roentgenogram cleared after a second episode of coughing associated with calcium flecks. Tests for histoplasmosis were positive. The final diagnosis was broncholithiasis due to histoplasmosis.

glands with the production of addisonian symptoms. Histoplasmosis is now considered to be one of the most common causes of Addison's disease.⁸ Some degree of caseation can be found in 76 per cent of the adrenal lesions produced by histoplasmosis,²⁵ but in spite of this great incidence of adrenal involvement in histoplasmosis, calcific deposits are seldom seen in the roentgenograms. This may be explained by the rapid course of the disease with fatal outcome when severe adrenal involvement occurs. Not enough time lapses for the caseated deposits to become sufficiently calcified to be seen in the roentgenograms. In some instances the protracted course of the disease permits enough calcium to be deposited in the lesions which are readily visualized in abdominal roentgenograms (Fig. 8A).

The liver is frequently involved in histoplasmosis and hepatomegaly may be the only presenting sign of disease. It is more

often associated with splenomegaly, particularly in children, and in cases of disseminated histoplasmosis. Fatal cases of histoplasmosis in children frequently show a large liver and spleen without signs of intrathoracic involvement (Fig. 8B). The benign cases with splenic involvement can be detected several years later when multiple small, round and concentrically calcified lesions are observed in the roentgenograms of these patients (Fig. 8C). Calcified lesions also occur in the liver but are rarely seen in the roentgenograms.

GASTROINTESTINAL MANIFESTATIONS

H. capsulatum has been found in almost every portion of the gastrointestinal tract. Ulcerations about the mouth have been reported in cases of histoplasmosis; they can also be found in the tongue, larynx and

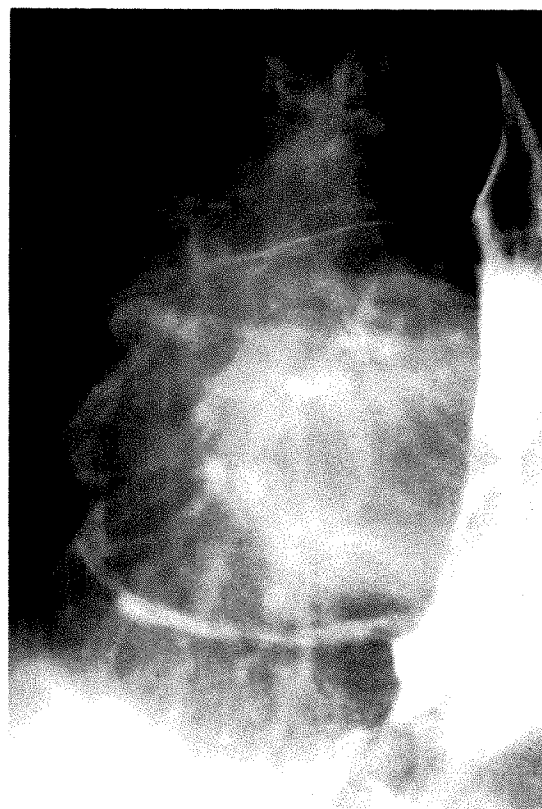


Fig. 7. Calcified pericardium in a patient with old histoplasmosis with positive skin test and negative tuberculosis workup. Pericardiectomy showed fibrosis and chronic inflammatory changes. Fungus was not isolated.

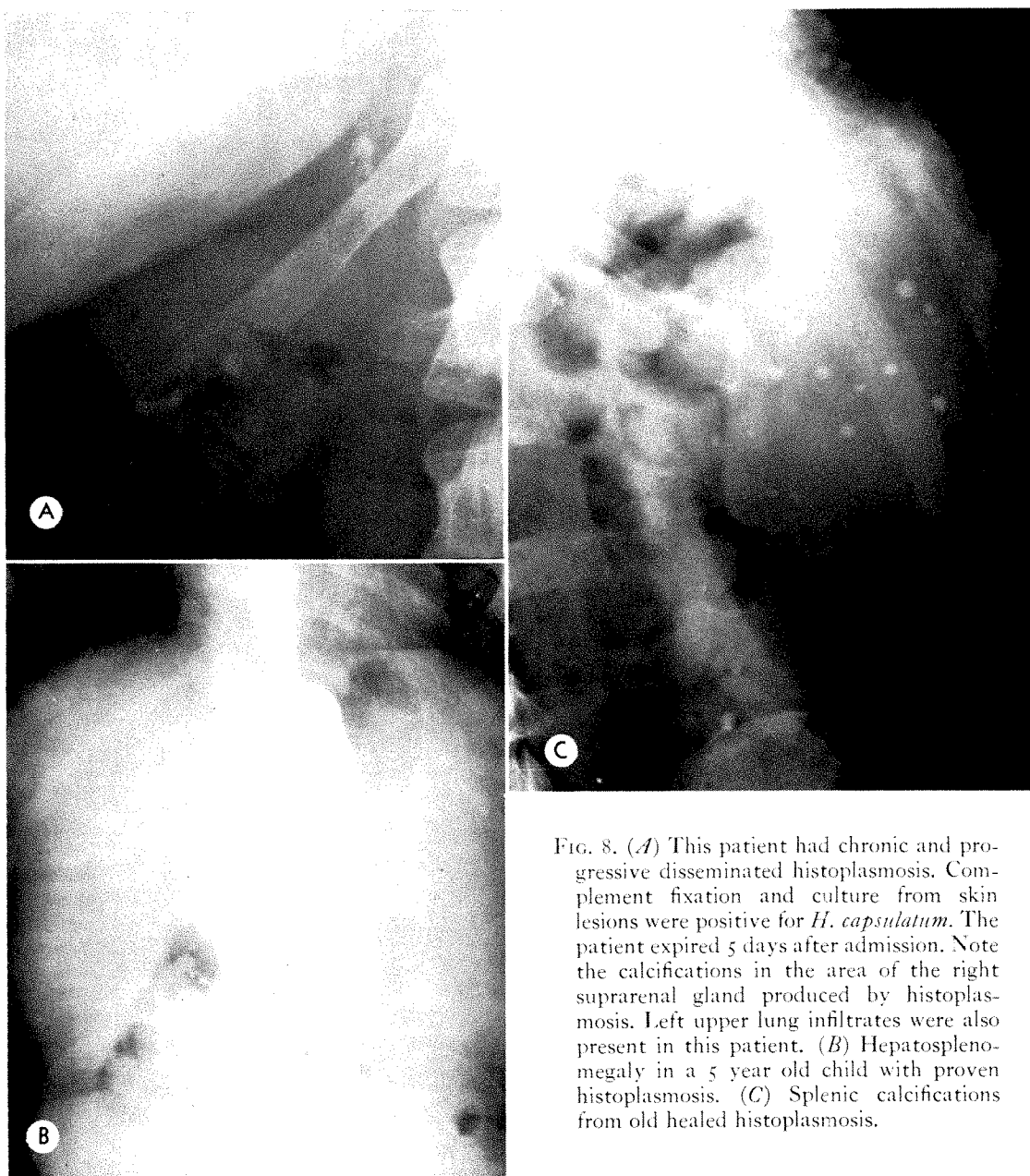


FIG. 8. (A) This patient had chronic and progressive disseminated histoplasmosis. Complement fixation and culture from skin lesions were positive for *H. capsulatum*. The patient expired 5 days after admission. Note the calcifications in the area of the right suprarenal gland produced by histoplasmosis. Left upper lung infiltrates were also present in this patient. (B) Hepatosplenomegaly in a 5 year old child with proven histoplasmosis. (C) Splenic calcifications from old healed histoplasmosis.

epiglottis where they may be mistaken for other conditions. No positive roentgen manifestations can be observed in these cases unless the lesions are large enough to cast a shadow in the roentgenogram (Fig. 9A).

Indirect involvement of the esophagus with the production of pulsion diverticula has been recently reported by Felson¹² in cases of histoplasmosis with mediastinal

involvement.

Fungi are known to be present within ulcerations of the gastrointestinal tract. Fitzpatrick and Neiman¹³ recently described a case of fatal hemorrhage from a gastric ulcer which contained *H. capsulatum* in its base and surrounding mucosa. As high as 20 per cent of patients with histoplasmosis have been reported to have gastrointestinal symptoms²⁹ and several

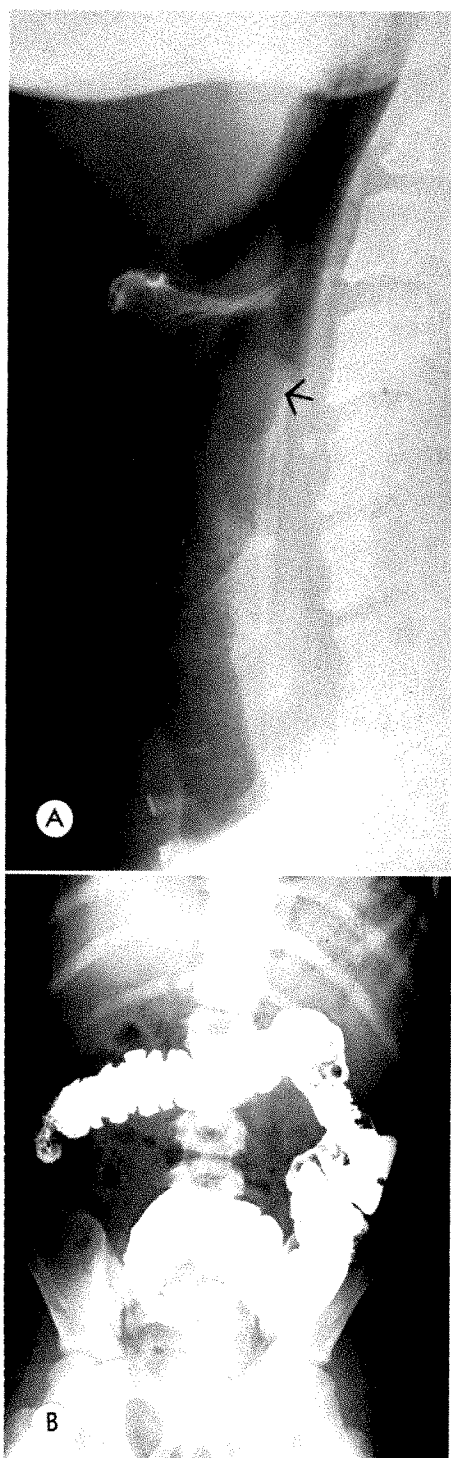


FIG. 9. (A) Fifty-five year old patient with chronic laryngitis due to inflammatory changes produced by histoplasmosis. Swelling and ulceration were noted in the supraglottic area. A soft tissue mass is seen in the roentgenogram. (B) Barium enema study in a patient with histoplasmosis since the

cases of intestinal involvement have been mentioned in recent reports dealing with cases where pathologic specimens were available.^{4,15,31} Ulcerative and pseudopolypoid lesions can occur in such cases in the small bowel and colon including the anus and rectum.⁶ The ulcerations are commonly small and superficial; they erode the mucosa and submucosa and cannot be seen in the roentgenograms. Deeper and larger ulcerations are rare and may cause perforation and peritonitis.²⁵ Pseudopolypoid formations have been reported in histoplasmosis and can be demonstrated in the roentgenograms;⁴ these are nonadenomatous, inflammatory pseudopolyps resulting from hyperplasia of the submucosa (Fig. 9B).

It is possible that cases of histoplasmosis have been misdiagnosed in the past as ulcerative colitis, enteritis and regional ileitis. Collins⁶ found that over 30 per cent of pathologic specimens of regional ileitis and chronic ulcerative colitis were histologically positive for histoplasmosis. The roentgenographic manifestations in such instances are no different from those found in cases where histoplasmosis is not the cause.

A high incidence of involvement by *H. capsulatum* has been noted in appendicitis and mesenteric lymphadenitis in juveniles.^{7,24} Roentgen manifestations can only be found when severe enlargement of the mesenteric lymph nodes occurs producing smooth extrinsic pressure defects in the adjacent bowel loops. More cases of gastrointestinal involvement could be discovered if histoplasmosis is kept in mind as a cause of these conditions.

OSSEOUS HISTOPLASMOSIS

Although the bone marrow is often the site of involvement in histoplasmosis, the reports dealing with bone lesions caused by this disease are scant. Key and Large¹⁸

age of 4. Polypoid masses were found in the rectosigmoid area showing lymphoid hyperplasia most likely due to reaction to *H. capsulatum*. Note the hepatosplenomegaly present.

reported on a patient with a localized lesion of the knee produced by *H. capsulatum*. An abscess cavity in the joint and articular surface erosion with necrosis were demonstrated. Extensive bone involvement has been observed in disseminated histoplasmosis.^{1,19} The roentgen manifestations were described as cortical thickening with widening of the medullary cavities of the long bones. Patches of osteoporosis and small areas of bone destruction at the epiphyses also occurred. Extensive bone marrow involvement was found at autopsy.

In localized bone involvement the roentgenographic findings will be those of a non-specific granuloma; destructive changes within the joint are observed with erosion of the articular surfaces and secondary sclerotic changes of the surrounding bone. The joint space is usually intact and the process seems to be localized (Fig. 10).

It is possible that more bony lesions caused by histoplasmosis will come to our knowledge as the incidence of discovery of this disease increases.

CENTRAL NERVOUS SYSTEM HISTOPLASMOSIS

Meningovascular and parenchymal brain lesions are observed in some autopsied cases with histoplasmosis.^{28,32} The lesions are commonly found microscopically in



FIG. 10. Right hip involvement in a 14 year old boy with a 14 month history. Chronic inflammation with abscess formation and marginal osteosclerosis were found. Fungi could not be isolated. Strongly positive reaction to histoplasmin was present.



FIG. 11. Calcification in the right frontal area of a 49 year old epileptic with suspected histoplasmosis infection of lungs and brain. The chest roentgenogram of this patient is shown in Figure 5C.

the base of the brain and around the vessels, simulating the granulomas found in tuberculosis. It is possible that the central nervous system involvement by *H. capsulatum* is more frequent than generally supposed. Not unlikely, some of the non-specific calcifications referred to as "brain stones"¹⁰ could represent old healed histoplasmoses (Fig. 11). A review of autopsy material should substantiate this possibility.

SUMMARY

A brief description is given of the regional roentgenographic manifestations which can be found in patients with histoplasmosis. Emphasis is placed on the rare and bizarre findings occurring in this condition. A plea is made for more careful study of pathologic specimens when the radiologist suggests the possibility of histoplasmosis, after discovering suspicious roentgenographic signs.

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ROENTGEN FINDINGS IN TERMINAL BRONCHIOLAR CARCINOMA*

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TERMINAL bronchiolar carcinoma, although a rather uncommon primary neoplasm of the lung, does have special clinical significance. This fact is supported by its terminology for it has been variously called alveolar cell carcinoma, pulmonary adenomatosis, alveolar cell tumor, jaagsiekte disease, primary multiple carcinoma, multiple nodular carcinoma, diffuse lung carcinoma, carcinosis, encephaloid carcinoma and carcinomatoides alveogenica multacentrica. Interest in terminal bronchiolar carcinoma has been broadened because of its apparent relationship to certain pulmonary lesions in horses, mice²⁹ and sheep.^{4,7,32} The lesions in sheep are quite similar to those in the human being, but any etiologic relationship between the two is still speculative.^{3,6,11,32}

Although the literature is extensive, there has been only one study chiefly concerned with the roentgen findings of this pulmonary cancer.³³ It is our purpose therefore to present the results of a study of 36 histologically proved terminal bronchiolar carcinomas, carefully selected on the basis of current pathologic concepts, accompanied by a review of the medical literature from the viewpoint of roentgen diagnosis.

The expanding scope of roentgenology makes it no longer adequate for the diagnostician to consider only the general diagnosis, cancer of the lung, foregoing any attempt to identify the known pathologic types. Of course, no histologic variety has only one specific roentgenographic pattern. However, our experience has been that certain forms of pulmonary cancer do tend to produce somewhat uniform roentgenographic appearances, although naturally considerable overlap exists in this regard.

REVIEW OF LITERATURE AS CONCERNS ROENTGENOLOGIC DIAGNOSIS

Until about ten years ago, reports of individual cases and articles based upon two or three cases were encountered. Such patients were usually symptomatic and their roentgenologic findings indicated extensive and often bilateral disease.^{1,2,5,6,8,10,11,12,13,14,16,17,18,20,21,23,24,25,27,28,31}

In 1950, 12 cases of terminal bronchiolar carcinoma were reported with detailed histories of each.⁹ All of these patients were symptomatic. Half showed involvement of only one lobe while in the other half the lesions were more diffuse and usually were bilateral. Rather extensive initial disease was shown and no well-defined, single nodules without contralateral spread were included. However, only two cases exhibited peribronchial nodal disease.

Later the same year four additional examples were reported.¹⁴ The roentgen features consisted of widespread areas of separate or confluent, poorly outlined, nodular densities without hilar lymphadenopathy. Serial films demonstrated relatively slow progression of the cancerous process. It is of note that one patient, a 58 year old female, presented herself during an acute respiratory infection. The roentgenogram of her chest revealed a patchy area of increased density in the base of the left lower lobe. This remained quite unchanged until thoracotomy 3½ years later. One month after operation, diffuse nodules appeared in both lung fields. This illustrates a point observed in this series, *i.e.*, a lesion may remain fairly localized and unchanged for a period and then suddenly spread, producing a diffuse infiltrative or nodular pattern involving both lungs.

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The same month, Paul and Juhl²⁰ reported observations on 8 patients. They indicated that the commonest roentgen appearance was that of single or multiple areas of homogeneous density resembling pneumonic consolidation. They found no evidence of mediastinal lymphadenopathy or pleural involvement—points generally in keeping with the present experience.

Zheutlin *et al.*³⁴ suggested that characteristic changes in the bronchographic pattern were present which should make one consider a diagnosis of "alveolar cell carcinoma." They listed them as follows: (1) a uniform, diffuse, rather marked narrowing of the segmental bronchi; (2) rigidity and elongation of the bronchi; (3) filling rather than coating of the bronchi; and (4) lack of filling of the terminal ramifications of the bronchi or of the alveoli of the lung segments supplied by these bronchi.

We are unaware of confirmation of these findings and, in fact, a case seen recently demonstrated quite different bronchographic appearances (Fig. 1).

Kirklin and McDonald¹⁵ also discussed alveolar cell cancer of the lung. They found

that these tumors usually showed poorly defined areas of consolidation, sometimes confined to part of a lung, but often these were more diffuse, involving both lungs.

Spain³⁶ reported 12 cases of terminal bronchiolar carcinoma associated with chronic inflammation and fibrosis. Six patients had multiple nodules and six had a solitary tumor.

Watson and Smith³⁰ reviewed 33 patients with terminal bronchiolar carcinoma. While their comments on the roentgen findings also indicated that the single, peripheral density was the commonest, there was no attempt at a full analysis of the roentgen diagnosis of this neoplasm.

More recently Woodruff *et al.*³³ reported on 16 cases of terminal bronchiolar carcinoma. They indicated that 40 per cent were less than 5 cm. in size and confined to one lobe. The tumors were fairly well-defined solitary lesions or multiple ill-defined infiltrates. Larger localized cancers, over 5 cm., comprised approximately 20 per cent of their series. The remaining cases showed diffuse disease in both lungs. In discussing the roentgenologic features, they indicated that the presenting shadow may vary considerably in size.

In summary the authors of reports on terminal bronchiolar carcinoma have usually stressed either the presence of diffuse nodular lesions involving one or both lungs or larger areas of consolidation. Not until recently^{26,30,33} has the localized, single lesion been recognized as a common form. Metastases were found in approximately 50 per cent and they were most frequently local, *i.e.*, within the thorax, involving the same lung, the opposite lung and the hilar and mediastinal lymph nodes. Distant metastases when present most often appeared in the liver, abdominal lymph nodes, bones and adrenal glands. Pleural effusion occurred occasionally. Apparently lymph node involvement was a relatively late manifestation in many instances.

MATERIAL

Histologic diagnosis was obtained either

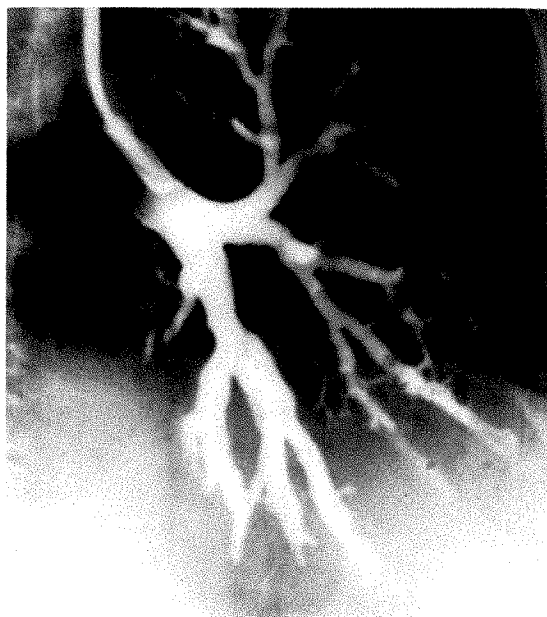


FIG. 1. Spot film from bronchographic series showing widened, filled and closely grouped bronchi surrounded by the terminal bronchiolar carcinoma.

by means of thoracotomy or post mortem. Twelve of the 36 patients came to autopsy and 24 had thoracotomy. In the thoracotomy group, 13 had a pneumonectomy, 8 a segmental resection, and only 3 had an open lung biopsy. All of these cancers, none of which were associated with a primary adenocarcinoma of other organs, were diagnosed by members of the attending staff of the Department of Pathology.

Details regarding current concepts of the pathologic identification of this cancer are supplied by Dr. Myron Melamed, Assistant Attending Pathologist. Bronchiolar carcinoma is a type of adenocarcinoma which appears to arise from the surface epithelium of small bronchi or bronchioles. Like carcinoma in general, it may range from a well differentiated tumor, composed of mature appearing cells, to very anaplastic cancer. The better differentiated bronchiolar carcinomas are composed of uniform, tall columnar cells which may or may not be mucus secreting and are often quite like the normal epithelial cells of the bronchial mucosa. The general tendency of bronchiolar carcinoma to grow along existing alveolar septa, often respecting anatomic segmental and lobar boundaries, is sometimes quite striking. It often remains apparent even when the tumor fills in alveolar spaces and forms sizable solid masses. If mucus secretion is marked, pools or lakes of considerable size may form within loculated and intercommunicating cystic spaces.

From time to time fibrous or fibrocaseous scars resembling burned-out tuberculous granulomas are found in intimate association with bronchiolar carcinoma. This relationship may be noticed particularly in surgically resected specimens when the tumor is localized and still small. Necrosis within the carcinoma itself is uncommon compared with other types of lung cancer. This type of change is practically confined to those bronchiolar cancers which are poorly differentiated.

Metastases occur via lymphatic and

blood channels. Intrapulmonic dissemination and regional lymph node involvement characteristically precede distant metastases. Multiple unilateral or bilateral separate tumors may be present in the lung without evidence of other metastases. This is variously believed to be the result of lymphatic spread, multicentric origin, or dissemination by aspiration and implantation. It may be so extensive as to cause death without distant metastases.

Adenocarcinomas of major bronchi may be similar histologically to some of the terminal bronchiolar carcinomas. They were not included in this study, nor were the rare adenocarcinomas arising in submucosal bronchial glands.

The age range was 42 to 74 years, and at the time of discovery of the lung cancer 6 patients were asymptomatic. The availability of adequate roentgenograms of the chest was a condition of acceptability in the series. Thirteen cases were fluoroscoped, but no additional findings of consequence were revealed. The time interval between detection of the neoplasm and thoracotomy ranged from 1 month to 5 years with the usual interval being 1 to 3 months. In the 12 cases coming to autopsy without thoracotomy, the duration of disease was 1 month to 3 years.

Roentgenographic survey of the bones which was carried out in only about one third of the cases revealed lytic metastases in 4 patients. In one there was involvement of ribs, humerus (Fig. 4D), and pelvis, in the second the pelvis alone was invaded, in the third the skull, femur and vertebrae were affected and in the fourth only ribs were sites of destruction. If more patients had had skeletal surveys, additional lesions might have been discovered, but it is not the policy to do a skeletal examination routinely on every patient with lung cancer.

Roentgenographically, local rib invasion was not noted. However, one patient at thoracotomy was found to have a non-resectable cancer due to involvement of the chest wall and the mediastinum. Another

case, presenting initially with a single nodule, showed diffuse pleural plaques of metastases 4 months later at autopsy.

The clinical course varied strikingly, not only within the individual roentgen groups but between the different groups as well. Some single nodules remained relatively stationary over a 2 to 3 year period, while other solitary nodules spread rapidly and became diffuse bilateral disease within a few months. Infiltrative lesions tended to do poorly with half of the patients dying within 4 months.

ROENTGEN DIAGNOSIS

Nodular Form. Eighteen cases had a single, well-circumscribed nodule. These coin-like densities were equally distributed throughout the pulmonary fields (Plate 1). Their size varied from $1\frac{1}{2}$ cm. in diameter to the largest mass measuring 10 cm. However 14 were under 3 cm. Four had a margin that was somewhat ragged, but most were clearly outlined and spherical.

Four of the nodular densities were of special interest to us because they contained a few poorly defined, 1 to 2 cm. radiolucencies scattered throughout the lesion (Fig. 2). These may represent foci of lobular emphysema or areas of normal lung not rendered airless, due to an irregular growth of the neoplasm. This feature may hold some degree of specificity for the roentgen diagnosis of terminal bronchiolar carcinoma.

Four tumors were followed for one to

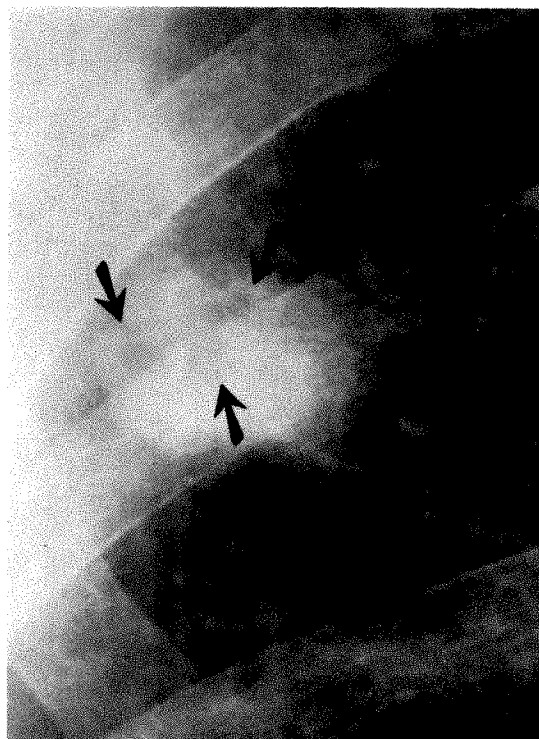


FIG. 2. One example from the group of 4 cases demonstrating small areas of radiolucency within the terminal bronchiolar carcinoma, nodular form.

three months with no interval change taking place in their roentgen appearance. Two nodules enlarged slightly in a four month period. One case during 3 months developed pleuritis and a few areas of disk atelectasis. Another round nodule, 2 cm. at discovery, grew to 7 cm. with slight lobulation and hilar lymphadenopathy in 10 months. Slight enlargement was seen in another



Explanation of Plate I

Solitary Nodular Form. Top: (A-R) Diagrammatic representation of the roentgen appearance of all cases presenting a coin-like or nodular density. B, G, H, I illustrate the 4 cases showing a vacuolated texture on the original roentgenograms.

Infiltrative Form. Middle: (A-I) Cases showing an irregularly bordered density, varying greatly in size and appearing often as a patch of pneumonia.

Segmental Form. Bottom, upper row: (A-E) As contrasted with the infiltrative form, the cases in this group tended to follow a segmental or lobar distribution. This was evident when lateral, oblique and stereoscopic roentgenograms were studied.

Unclassified. Bottom, lower row: (A-D) These 4 dissimilar cases, presenting multiple nodules, a massive effusion and bulky lymph node involvement on the contralateral side, fail to correspond to the morphologic characteristics of the three main groups.

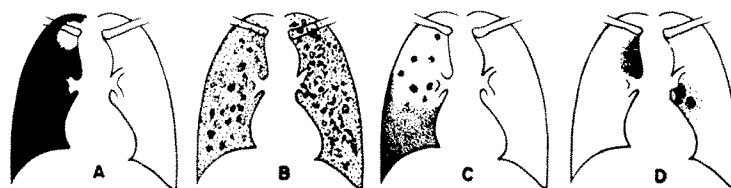
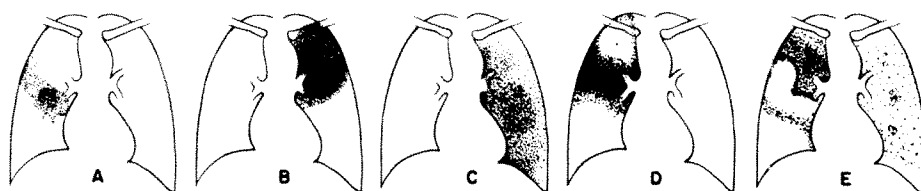
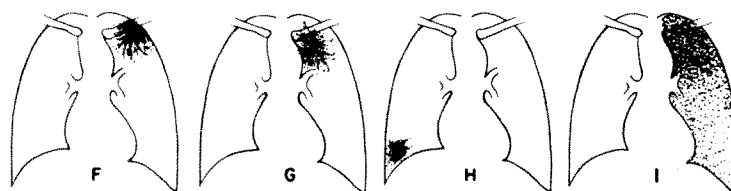
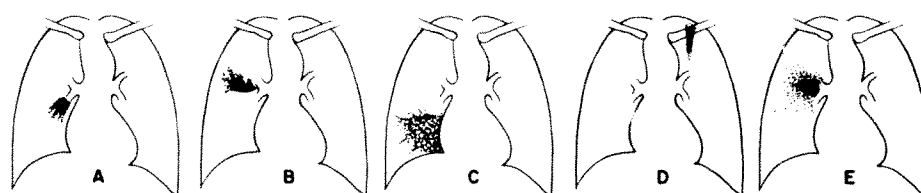
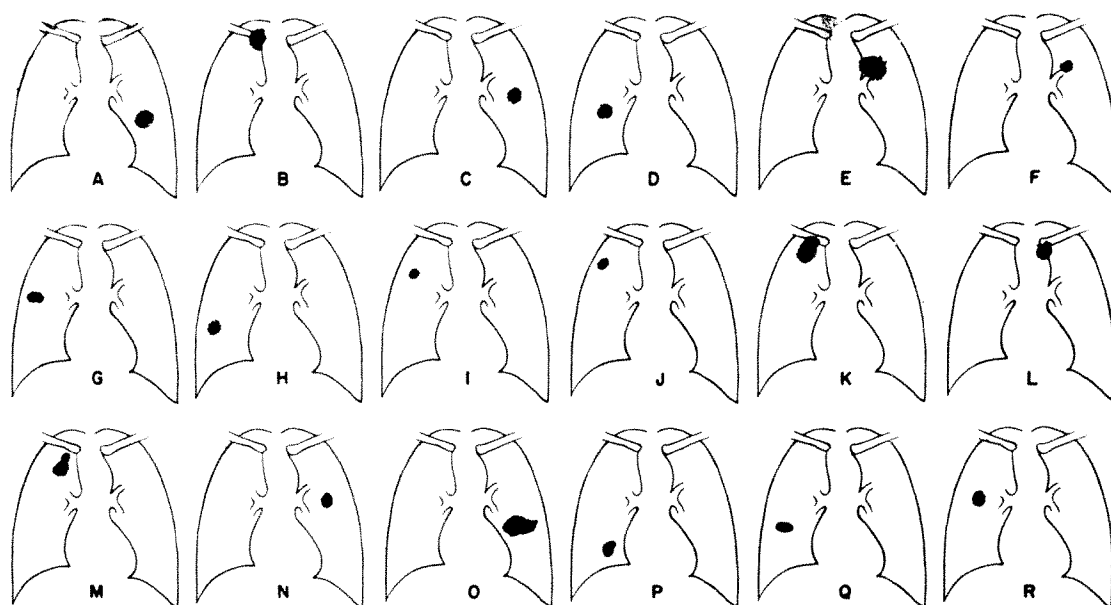


PLATE I

lesion which was followed for one year. Still another doubled in size in 2 years and a third showed an increase to 4 times its original size in 3 years.

Infiltrative Form. Nine tumors presented roentgenographically as infiltrates (Plate 1). The size varied from a patchy irregular density measuring 2 cm. to somewhat circular areas 8 cm. in diameter with shaggy irregular borders.

The course of these patients varied considerably. Two died within a month of the first roentgenographic examination. Three patients who were followed from 2 to 4 months showed no roentgenologic change in their lesions with the exception of the development of slight lobulation in one. In one case a slight increase in size over a 2 month period was noted, while another patient developed an 8 cm. mass in the lung root in 4 months. One lesion increased 50 per cent in extent over a 2 year period.

Within this group are 2 patients who at the beginning had a local, solitary process and subsequently developed a diffuse pattern of involvement. The first showed infiltration in the right lower lung. Nine months later, an 8 cm. mass confluent with the right lung root with 1 cm. nodules in both lungs and an elevated right leaf of the diaphragm had developed. The second had

a 3 cm. ill-defined, infraclavicular infiltration which twenty-one months later had doubled in size. One month afterwards, diffuse nodules in both lungs were clearly demonstrable.

Segmental Form. Five cases presented lesions which appeared to follow a segmental distribution (Plate 1). Two caused a left upper lung consolidation, with slight lobulation and some degree of atelectasis. Three involved portions of the right lung. Two of these patients died within one month. One lived 7 months and another one year.

Unclassified Form. Four cases demonstrated a more varied pattern (Plate 1). One showed a patchy density in the right upper lung with a pleural reaction which became massive within one month. Another showed bilateral hilar enlargement with mediastinal masses and a 2.5 cm. nodule in the lingula. The third apparently started with diffuse disease producing a pattern similar to bronchopneumonia. The fourth showed a single nodule with patchy pneumonia. Three of these cases died in less than one year.

CASES OF SPECIAL SIGNIFICANCE

CASE I. A 61 year old female presented with patchy densities in the right mid and lower lung field and a minimal degree of pleuritis (Fig. 3). The roentgen appearance was that of bronchopneumonia. One month later the picture was relatively unchanged. A dose of 3,000 r was delivered to the area. The patient died 3 years later. At autopsy the right lung was diffusely involved and there were metastases to the ribs.

CASE II. A 51 year old white male denied previous chest disease. A routine chest examination revealed a shadow in the right mid lung zone, but no action was advised (Fig. 4A). Five months later dyspnea occurred, the patient was hospitalized and a right pleural effusion was tapped (Fig. 4B). He became progressively weaker and approximately 6 months after the initial roentgen study a right supraclavicular lymph node was biopsied, revealing cancer. The patient soon developed bilateral disease (Fig. 4C) and an open lung biopsy revealed terminal bronchiolar carcinoma. Radiation therapy was

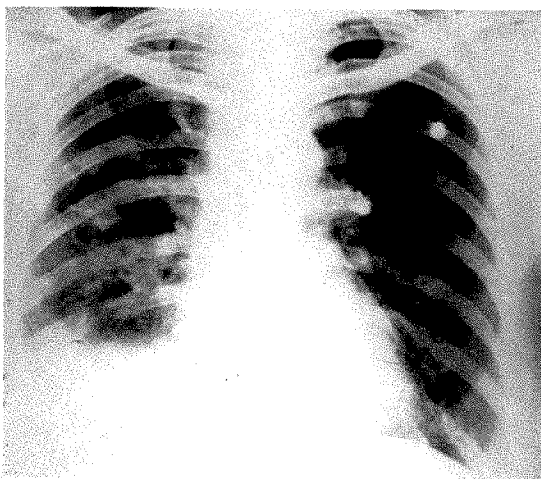


FIG. 3. Case I. Unclassified form showing a unilateral bronchopneumonic pattern with pleural effusion.

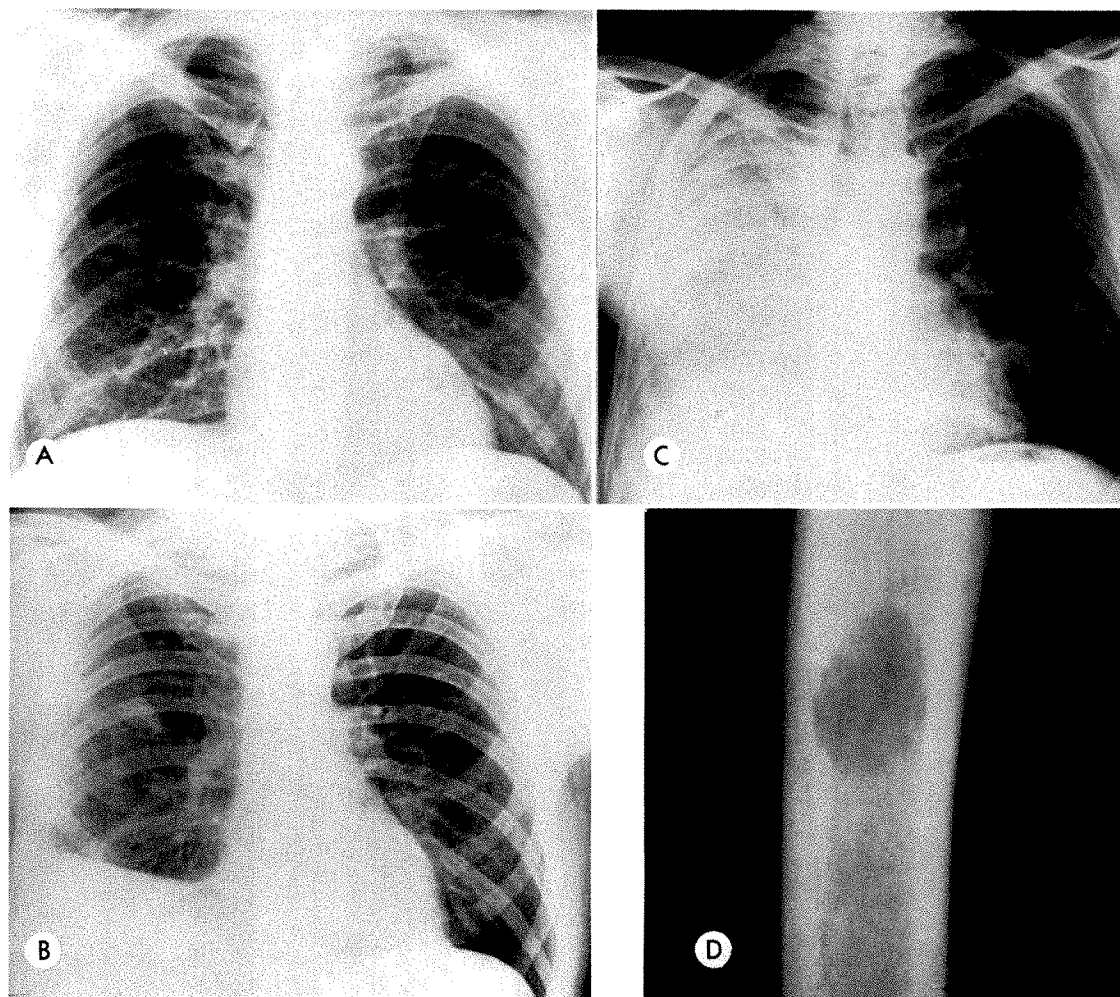


FIG. 4. Case II. (A) Solitary nodule of the mid portion of the right lung. (B) Several months later, showing the development of a pleural effusion and an increase in the size of the nodule. (C) Six months later an increase is seen in the pleural reaction. The right lung is largely infiltrated and 2-3 mm. nodules have appeared evenly distributed throughout the left lung. (D) Characteristic metastasis to the shaft of the humerus.

started, but the patient expired in a month, or 8 months following the initial roentgenographic examination.

CASE III. An operating room employee at the age of 62 developed a roentgen shadow in the right lower lobe. There was a poorly defined patchy infiltration measuring approximately 2 cm. It so happened that this was followed over a 3 year period at which time it was seen to have increased slightly in size (Fig. 5). Finally, 3 years after the roentgenologic discovery of this lesion the patient underwent a thoracotomy and right radical pneumonectomy. No lymph nodes appeared to be involved. The

pathologic diagnosis was terminal bronchiolar carcinoma. The patient is alive and well 11 years following the discovery of her cancer.

CASE IV. A 60 year old female developed a nodule measuring 3.5 cm. in diameter with fairly distinct borders in the right mid lung field. She was asymptomatic and was followed over a three year period during which time the lesion remained localized, but increased in size by four times (Fig. 6). Three years following the discovery of the cancer, a thoracotomy and segmental resection of the right middle lobe were done. The patient is now alive and well 6 years following thoracotomy.

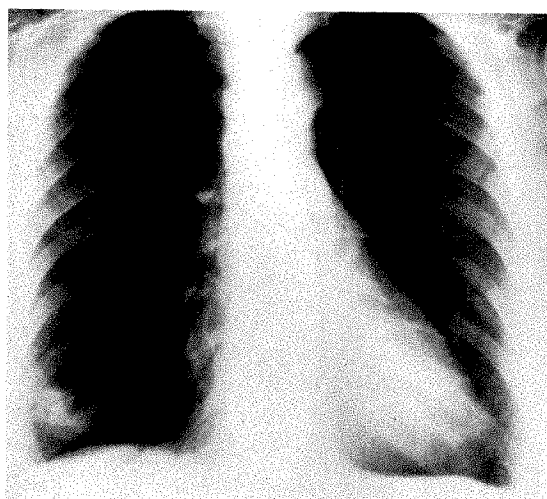


FIG. 5. Case III. Infiltrative form of terminal bronchiolar carcinoma. When first noted three years previously on a photoroentgen film, its appearance was not substantially different.

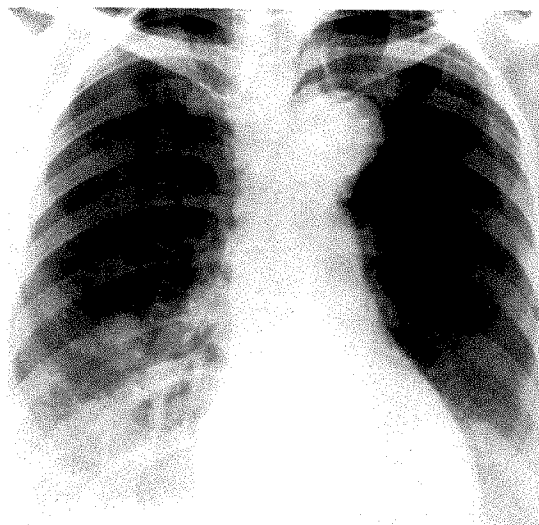


FIG. 6. Case IV. Nodular form of terminal bronchiolar carcinoma which three years previously presented a similar appearance except that it was approximately one fourth the size.

SUMMARY AND CONCLUSIONS

1. The literature on terminal bronchiolar carcinoma has been reviewed from the standpoint of roentgen diagnosis.

2. Thirty-six histologically proved terminal bronchiolar carcinomas have been studied in regard to their roentgen appearance.

3. Eighteen presented as localized nodules in the lung, 9 as single infiltrations, 5 as segmentally located areas of consolidation and 4 with sufficient variation as to render them unclassifiable.

4. The course of terminal bronchiolar carcinoma was evaluated by a study of serial roentgenograms. It was found that some of the diffuse bilateral lesions began as a localized nodule. There was a wide variability in growth rate and course of this pulmonary cancer.

5. Lymph node involvement and pleural reaction were often relatively late occurrences.

6. The response of these tumors to irradiation apparently presents no feature specifically related to their recognition by diagnostic roentgenology.

7. The single nodular form in a few in-

stances may present a somewhat specific roentgen pattern.

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ANGIOGRAPHY AS A MEANS OF DETERMINING RESECTABILITY OF PRIMARY LUNG CANCER*

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ANGIOGRAPHIC examination of the heart and great vessels in the mediastinum to determine local extension of primary lung cancer has been used in some centers for many years.⁶ The method has achieved good results but for several reasons has not found universal acceptance. This report comprises experience with 100 pathologically proven cases.

The reasons which prompted our use of angiography are three: (1) statistics which show a steady increase in the incidence of lung cancer (Fig. 1); (2) the fact that in spite of intensive preoperative assessment, two of every three patients subjected to thoracotomy proved in the past to have a non-resectable lesion;⁴ and (3) evidence to suggest that surgical exploration of the patient with non-resectable lung cancer may result in unduly rapid extension of the disease, the operation itself reducing mean life expectancy even though no resection is carried out.^{2,9}

TECHNICAL CONSIDERATIONS

A number 10 end-opening Lehman catheter is placed in the innominate vein or proximal superior vena cava under fluoroscopic control after venous cut down in the arm. Fifty-five ml. of contrast medium are injected by a Gidlund syringe and simultaneous biplane exposures obtained at a rate of two films per second for five seconds, followed by one film per second for five seconds. Urokon 70 per cent, hypaque 75 and 90 per cent, cardiografin 85 per cent, renografin 76 per cent and ditriokon have all been used. An Elema roll film serial

changer is employed and a pressure of 5 to 7 kg. per sq. cm.

Simultaneous anteroposterior and lateral views are used for right-sided lesions and two oblique views for left-sided lesions. Some recent cases have been examined with cinerentgenographic technique employing a Marconi 12-inch image intensifier.

SELECTION OF CASES

Only patients with hilar lesions, or with lesions in close relationship to the mediastinum, were chosen. Angiography was employed after clinical and laboratory study, which included bronchoscopy, barium examination of the esophagus during fluoroscopy, tomography and cytology of sputum. A scalene lymph node biopsy was done in twenty instances, and was negative in all but one. Skeletal survey and examination of pleural fluid cytology were done when indicated. The criteria of non-resectability excluding angiographic findings are listed in Table I.

The angiographic criteria of non-resectability, which form the basis of this study,

TABLE I
CRITERIA OF NON-RESECTABILITY

- | |
|--|
| 1. Tracheal or carinal involvement on bronchoscopy |
| 2. Recurrent laryngeal nerve paralysis, phrenic nerve paralysis, or Horner's syndrome |
| 3. Positive pre-scalene lymph node biopsy |
| 4. Roentgenologic involvement of chest wall (non-resectable), esophagus or opposite lung |
| 5. Superior vena caval obstruction |
| 6. Recovery of malignant cells from pleural fluid |
| 7. Distant metastases |

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are as follows: Any persistent filling defect or narrowing of the superior vena cava, right atrium, or left atrium was considered to indicate the presence of non-resectable disease. Any involvement proximal to the bifurcation of the right pulmonary artery, or within the proximal 1.5 cm. of the left pulmonary artery, or within the terminal 1-2 cm. of the four major pulmonary veins also rules out resection. The terminal portions of the pulmonary veins can be filled by reflux of contrast medium from the left atrium when the pulmonary artery on the side of the reflux is occluded.¹³

Minor degrees of displacement of the superior vena cava, the pulmonary arteries or veins correlate well with metastases in the regional lymph nodes in these areas. At operation the involved lymph nodes can, on occasion, be dissected and removed. Also, an intrapericardial dissection and ligation of the pulmonary veins may, on occasion, be feasible. Displacement alone, therefore, is not an absolute indication of non-resectability.

Variation in caliber of the pulmonary

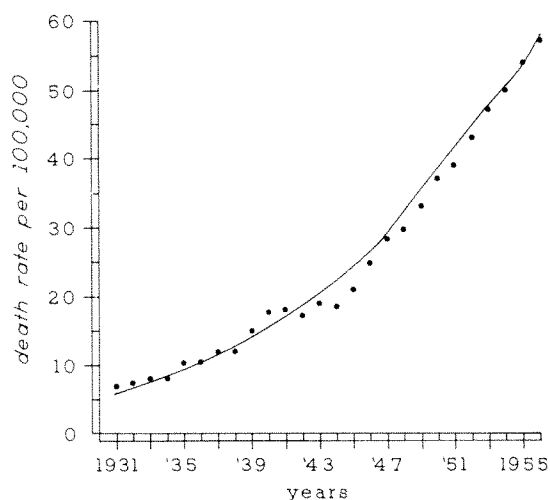


FIG. 1. The standardized death rate for lung cancer in Canadian males from 1931 to 1956 is shown for ages 35-84 years, illustrating a fairly uniform and progressive increase over this time interval. (Courtesy of Dr. A. J. Phillips.)

arteries is measurable on the static films according to the phase of the cardiac cycle. A failure to show expansion in systole has been readily observed, particularly in the cine films where there is a striking reduc-

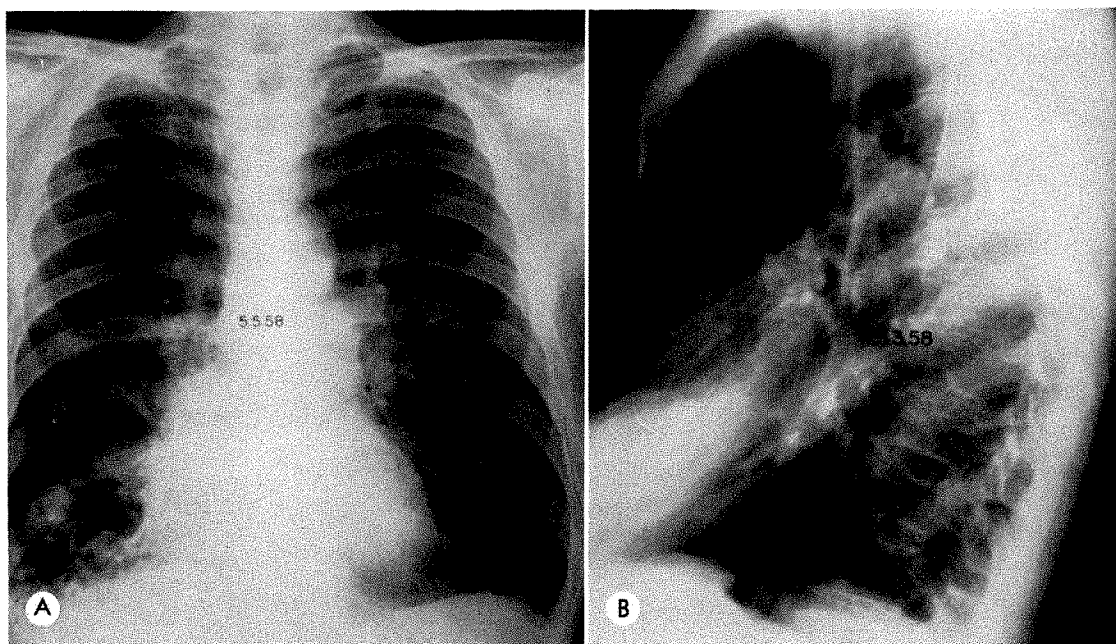


FIG. 2. S.P. (A) Plain posteroanterior and (B) lateral roentgenogram showing paramediastinal collapse and consolidation in right middle lobe. The lateral roentgenogram shows biconvex configuration consistent with a mass within the predominantly involved medial segment.

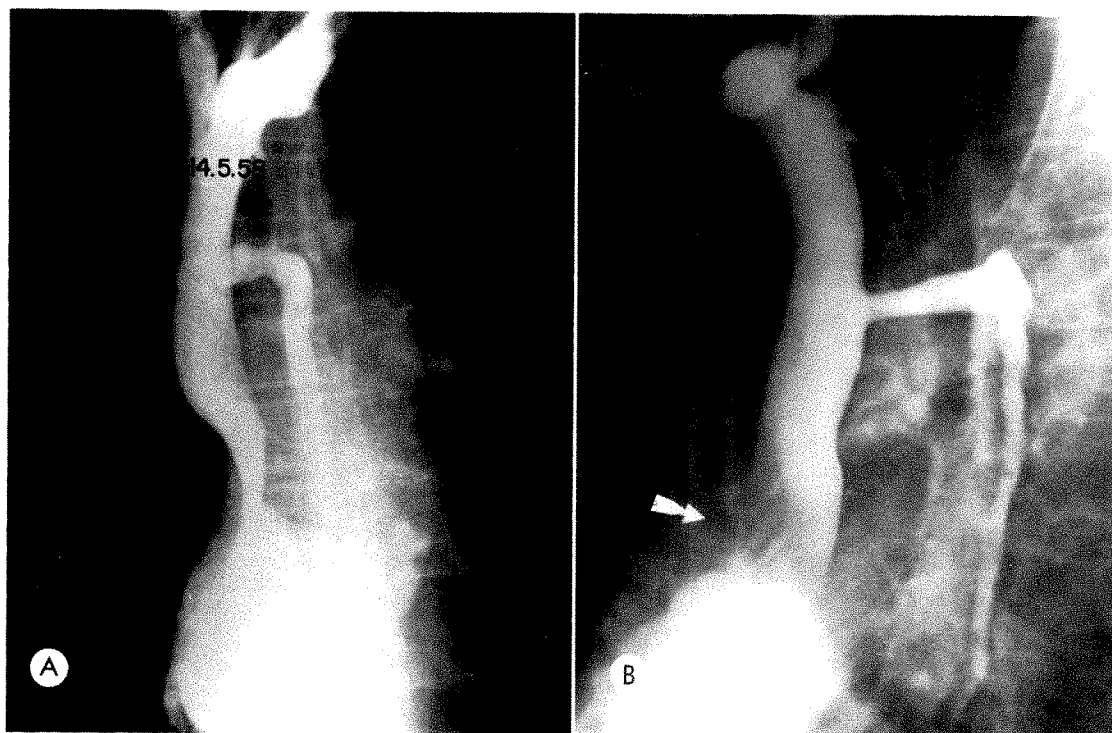


FIG. 3. S.P. (*A* and *B*) Same case as in Figure 2 confirming the presence of a large mass involving the superior vena cava, adjacent right atrial wall and overlying pericardium. Proven non-resectable at thoracotomy. Note reflux into azygos vein due to partial superior vena caval obstruction.

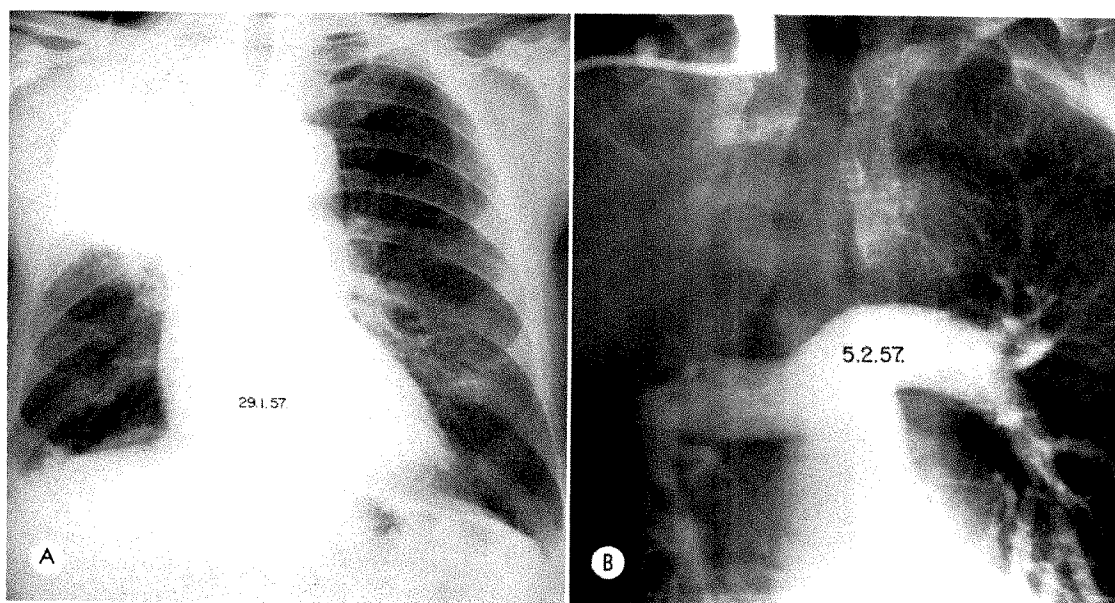


FIG. 4. W.S. (*A*) Complete right upper lobe consolidation with slight loss of volume and pleural reaction. (*B*) Frontal angiogram shows obstructed right upper lobe artery, and, in addition, nodular filling defects on the superior aspect of the right pulmonary artery proximal to its bifurcation. The lesion is non-resectable.

tion in the flow through the involved segment. One advantage of the cine is the facility of viewing the injection sequence on a TV monitor as it occurs so that if the desired image is not obtained or position is not optimal, these can be corrected and the injection repeated. We have varied the technique in more recent cases, adding multiple injections with more selective use of the catheter.

RESULTS

Of the 100 patients, 42 were considered to have resectable lesions. Because of co-existing emphysema, cardiac disease, or other disability, only 32 were suitable candidates for thoracotomy. In 29 the predicted absence of involvement of the heart and great vessels was confirmed. There were 3 patients who had spread to the heart or great vessels not recognized preoperatively. Interestingly enough, all had carcinoma in the left upper lobe bronchus.

The errors in the 3 cases reflected an inability to recognize local metastasis in the

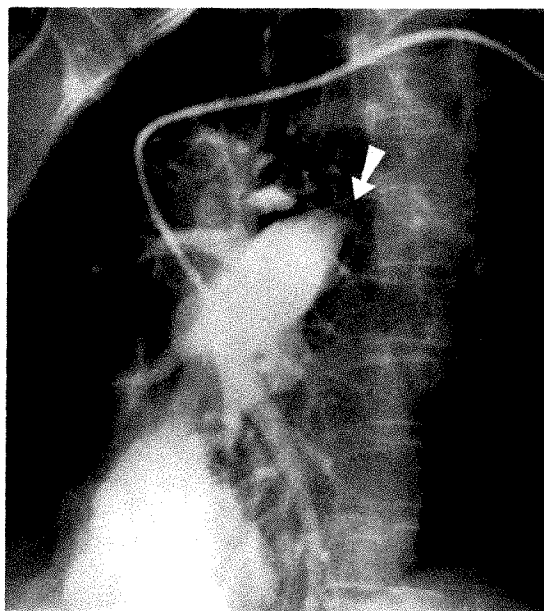


FIG. 5. A.L. Left oblique angiogram. The arrow indicates the site of complete obstruction of the left pulmonary artery at its origin. The primary lesion in the left upper lobe bronchus was non-resectable as confirmed at thoracotomy.

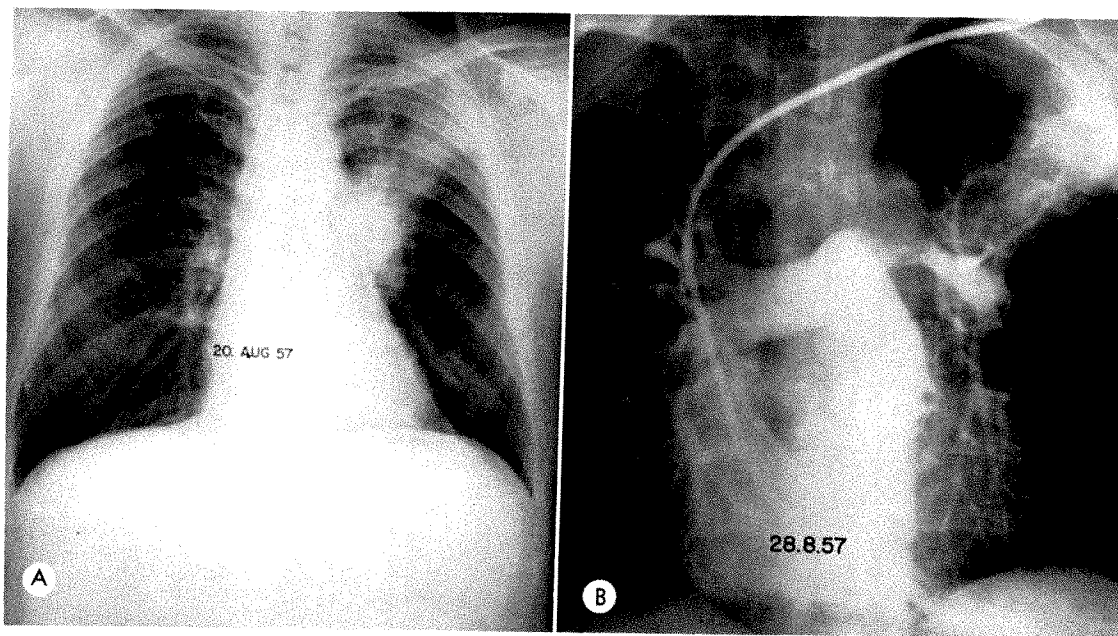


FIG. 6. W.M. (A) Left hilar mass and upper lobe infiltration discovered on survey roentgenogram. (B) Gross annular involvement of the left pulmonary artery with extension to the main pulmonary artery. Non-resectable lesion. No thoracotomy was performed.

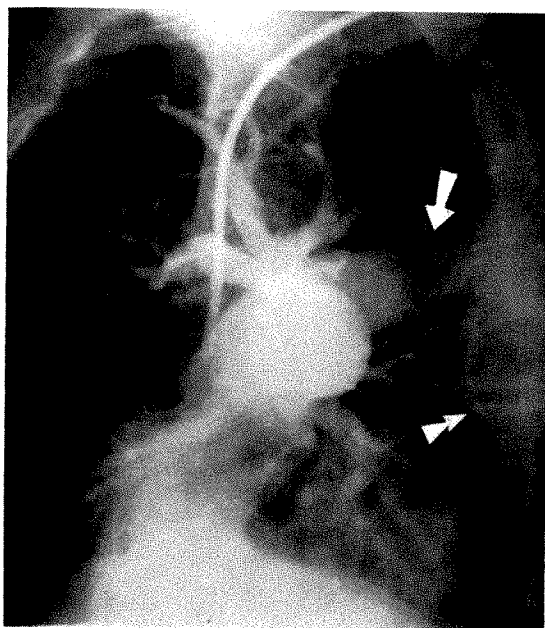


FIG. 7. D.T. Left oblique angiogram showing annular constriction of the left pulmonary artery, 2-3 cm. beyond its origin (upper arrow), due to a ring of lymph node metastases. The lower arrow indicates the primary lesion in the apical segment of the left lower lobe. The lesion is resectable.

posterior aspect of the left lung root (Table II). Review of the angiograms brought two

TABLE II

RESULTS OF 100 CASES EXAMINED BY ANGIOGRAPHY*

Resectable		Non-Resectable	
42	100 Angiograms	58	
32	50 Thoracotomies	18	
3	Errors	0-1	
29	46	17	

* One case in the non-resectable group was considered to be an error in interpretation for statistical purposes but there was a long time interval and radiation therapy prior to thoracotomy (See text).

points to light. In the first place, the presence of left upper lobe collapse of a considerable degree was noted in these cases, and secondly, the degree of rotation of the thorax might have been more advantageously selected to project the left pulmonary artery in a plane as nearly parallel to the film as possible to insure good visualization of its length. The areas of involvement found at thoracotomy are detailed below:

CASE No. 29 (P.F.). There was a cone-shaped occlusion of the artery to the left upper lobe. The corresponding vein therefore did not

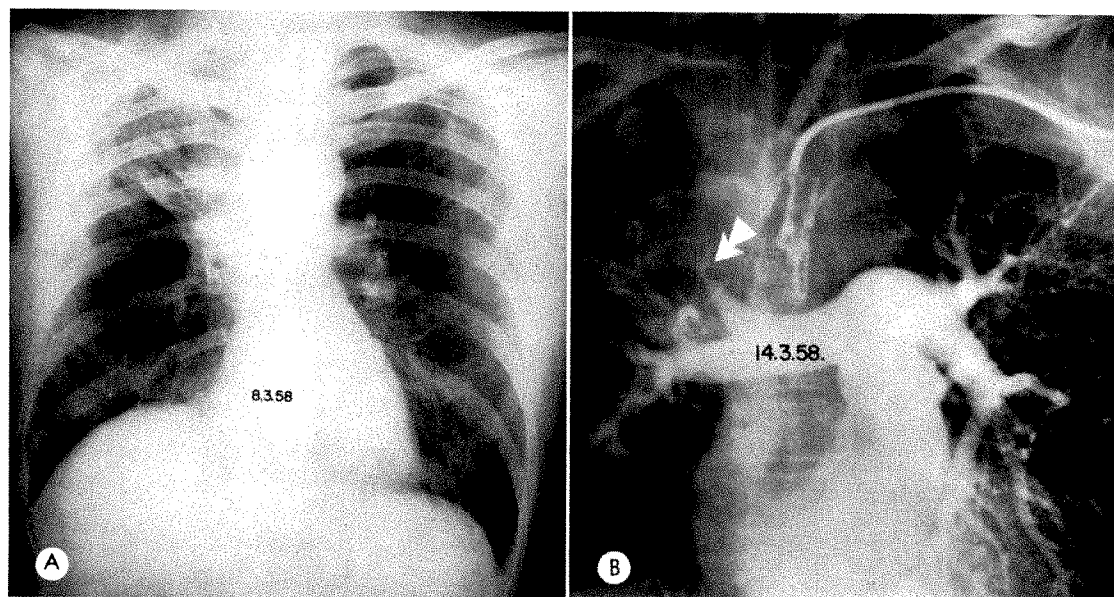


FIG. 8. J.F. (A) Right upper hilar mass, infiltration and partial collapse of the right upper lobe on plain roentgenogram. (B) Angiogram shows conical obstruction of the right upper lobe artery (arrow) but no involvement of the main artery. Pneumonectomy was performed and the findings were confirmed.

opacity and could not be assessed. At thoracotomy the involvement of the left upper lobe artery was found to extend proximally to the left main pulmonary artery, the anterior vein and adjacent pericardium and this extension was not demonstrated angiographically even in retrospect (Fig. 9).

CASE No. 65 (A.P.). A lobar arterial obstruction in the left lung root almost identical to Case 29 was seen. Thoracotomy showed involvement of the pericardium and left atrial wall.

CASE No. 74 (W.E.). The one patient who had a positive pre-scalene lymph node biopsy, with left upper lobe carcinoma and no demonstrable abnormality in the angiogram, underwent operation for the purpose of a palliative



FIG. 9. P.F. Left oblique angiogram showing an obstruction of the left upper lobe artery (upper arrow). No involvement of the left pulmonary artery was demonstrated. Thoracotomy revealed plaque of tumor, extending to the left pulmonary artery without narrowing, involvement of the anterior vein (not filled in the angiogram) and of the adjacent pericardium. The lower arrow indicates a mass in the left hilus with upper lobe collapse. This was the site of involvement of the anterior vein and pericardium found at thoracotomy which rendered this lesion non-resectable.

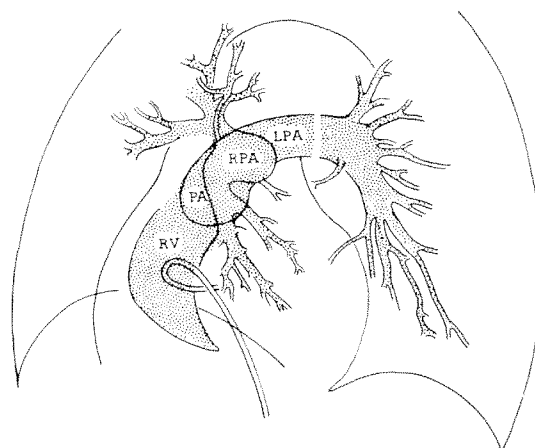


FIG. 10. Schematic drawing illustrating the arbitrary line 1.5 cm. from the origin of the left pulmonary artery separating the non-resectable lesions on the proximal side (Fig. 5 and 6) from the peripheral resectable lesions (Fig. 7). LPA=left pulmonary artery; RPA=right pulmonary artery; PA=pulmonary artery; RV=right ventricle.

lobectomy. Surgical exploration revealed lymph node metastases surrounding the left pulmonary artery and extending up the trachea. It was decided that lobectomy was therefore technically impossible.

Three patients had spread to the pleura or chest wall which prevented curative resection but the major vessels were uninvolved as predicted from the angiogram. Three others had more extensive lymph node involvement than suspected from all of the preoperative investigations but these were resectable and the great vessels were not involved.

There were 58 patients whose angiograms were interpreted as showing non-resectable disease. Eighteen of these patients were subjected to thoracotomy. These 18 patients were good operative risks, in the younger age range, and had no other firm contraindications to pneumonectomy. In 17 of these the angiographic findings proved to be correct and no excision could be attempted. The one remaining patient was submitted to a course of cobalt beam therapy and seven months later had a successful pneumonectomy at another hospital. This patient died six months

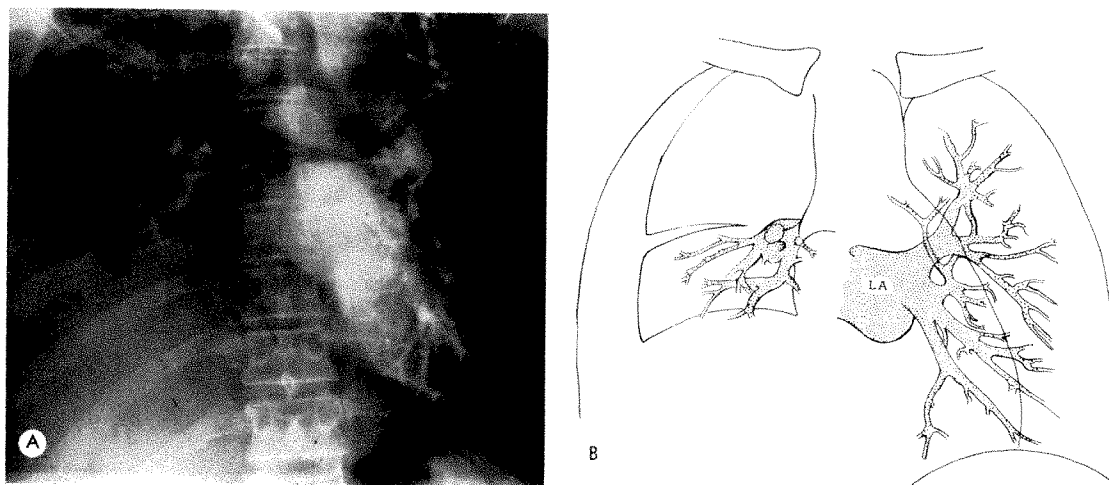


FIG. 11. D.L. (A) Anteroposterior angiogram of a small right upper lobe lesion, the venous phase demonstrating left atrial filling defect. There is a large effusion on the right side with absence of filling of the right pulmonary veins and some stasis of contrast medium in the right lower lobe. At operation there was gross infiltration of the left atrium by the neoplasm. (B) Line drawing of A. LA=left atrium.

after surgery with local and distant metastases. The angiographic findings therefore were correct in 17 of 18 cases, and may have been correct in all 18, though this could not be proven because of the interval between investigation and pneumonectomy, and the effect of radiation therapy in producing regression in the local extent of the disease.

The remaining 40 patients had angiograms which were interpreted as showing non-resectable disease, and they did not have a thoracotomy. This conservatism was considered justifiable in view of gross involvement of the major vessels.

SUMMARY

Of 100 patients examined, 50 had surgical exploration. The angiographic interpretation correlated accurately with the operative findings in 46. The posterior aspect of the left upper lung root was least accessible to accurate interpretation in our hands. Most of our patients had left-sided lesions. Surgical exploration was carried out in patients with no other contraindications to surgical treatment if there were equivocal angiographic findings.

Those patients not submitted to thoracot-

omy demonstrated in our opinion incontrovertible evidence of non-resectability. This judgment was based on the operative proof in 17 cases considered non-resectable by angiograms in which the neoplasm was seen to extend beyond the limits acceptable for curative resection.

A normal angiogram does not exclude intrathoracic extension remote from the heart and great vessels, and the procedure therefore does not replace accepted clinical and roentgenologic techniques in use for preoperative investigation. It is an informative and complementary procedure reserved for selected cases.

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THE ROENTGENOLOGIC SIGNS OF PEDUNCULATED PLEURAL TUMORS*

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PRI-MARY pleural tumors are rare. However, they are being recognized more frequently because of greater utilization of chest roentgenography.

Mesothelioma is the most common tumor originating from the pleura. Two gross pathologic types are recognized, diffuse and localized. The localized lesion occurs more frequently.⁵

It is noteworthy that localized pleural mesotheliomas are often pedunculated. Pedunculation occurred in 13 of 24 cases reported by Clagett *et al.*,³ in 3 of 8 cases reviewed by Stout and Himadi,⁵ and 2 of 6 cases studied by Thomas and Drew.⁶ Thus 30 to 50 per cent of localized mesotheliomas are attached to the pleura by a pedicle.

It has been emphasized that an intrathoracic mass, if accompanied by the clinical syndrome of chills and fever, migratory arthralgias, and clubbing of the digits, is very likely to be of pleural origin. Usually, however, such a tumor is detected as an incidental roentgenographic finding without associated clinical signs or symptoms. In this circumstance roentgenologic analysis is the only method by which a correct preoperative diagnosis can be made.

The absolute diagnosis of a pleural tumor based on roentgen signs may be difficult. A review of the literature indicates that a correct preoperative diagnosis is rarely made.^{1,3,4,6} In the evaluation of such a problem very little emphasis has been given to the importance of the fact that localized pleural tumors are often pedunculated. If the presence of a pedicle can be established, the pleural origin of the mass is proven.

ROENTGENOLOGIC SIGNS OF PEDUNCULATION

If very little of the surface of an intrapleural mass is attached to either of the pleural surfaces, the tumor is relatively free to move about in the pleural space. A pedunculated pleural mass has this characteristic.

Because of the remarkable mobility of these tumors, a striking change in the shape and density of the roentgenographic shadow they produce can occur on comparably projected and exposed roentgenograms. As pointed out by Blount² in one of his cases, this is due to change in the axis which the tumor presents to the roentgen ray beam. These phenomena can be observed best with inspiration and expiration roentgenograms and/or fluoroscopy (Fig. 1, A-D).

The presence of a pedicle may permit a marked change in the position of the mass in the thorax with change in the patient's position or after the production of a pneumothorax or hydropneumothorax (Fig. 2, A-F).

DISCUSSION

The importance of recognizing that an intrathoracic mass is pedunculated is considerable. This finding indicates with certainty that the mass is of pleural origin. Therefore it constitutes the most reliable sign of a pleural tumor. Because of the frequency of pedunculation of localized fibrous mesotheliomas, this entity becomes a likely diagnosis. The presence of a pedicle also indicates with considerable reliability that the tumor is benign. Further, it shows that the tumor can be ex-

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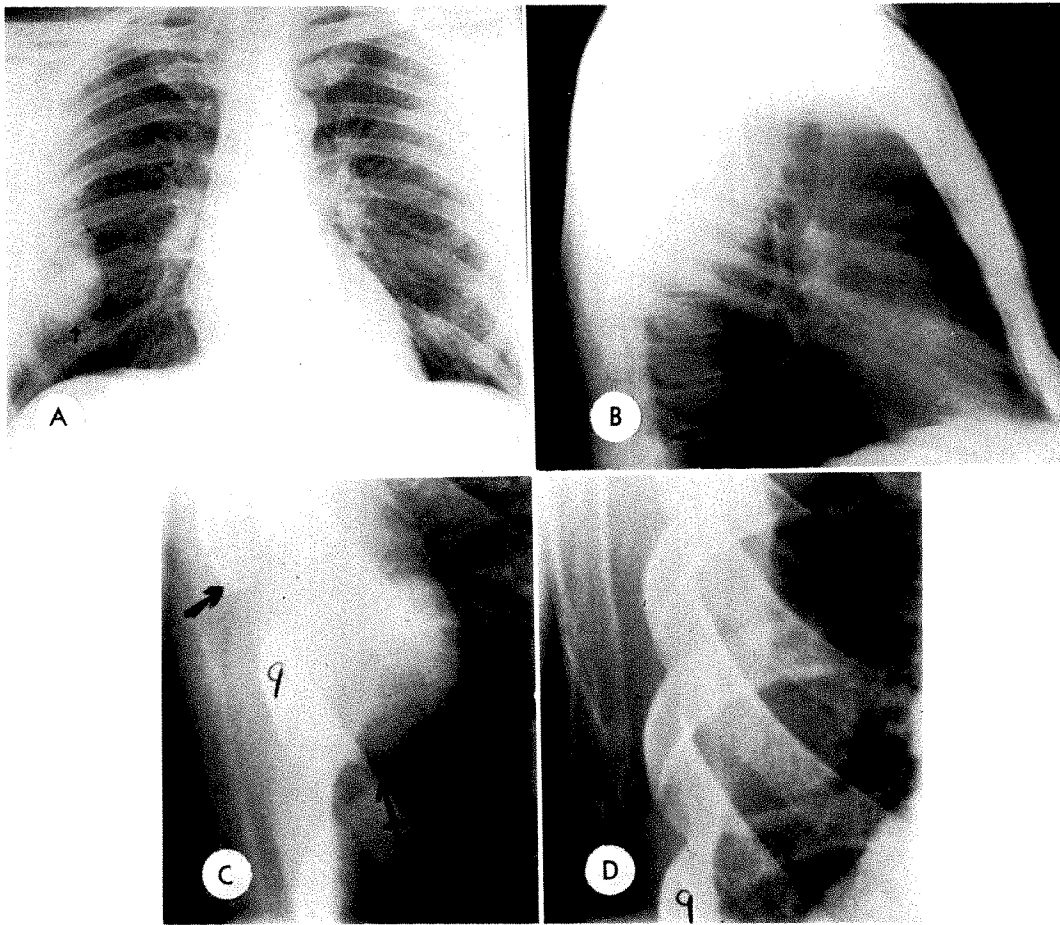


FIG. 1. An asymptomatic 59 year old white male was admitted for excision of a "lung tumor" found on routine chest roentgenogram.

(A and B) A sharply defined $6 \times 5 \times 4$ cm. shadow was seen posterolaterally in the right lower lung field. Erect, right anterior oblique spot roentgenograms were made in (C) inspiration and (D) expiration and document the following fluoroscopic findings: 1. Caudad movement of the shadow on deep inspiration. Note the changing relationship of the shadow (†) to the scapula (↑) and the posterior ninth rib indicating that it is not a sessile parietal pleural mass and that it is not extrapleural; 2. apparent decrease in density of the shadow during expiration suggesting rotation of the axis of the mass with respiratory movement; 3. change in shape of the shadow; on inspiration the shadow shows a lobular outline while on expiration it is smoothly curved. These findings indicate a lobulated mass movable within the pleural space, *i.e.* a localized pedunculated pleural tumor.

At thoracotomy a smooth encapsulated, bosselated mass was found in the right pleural space attached to the visceral pleura of the upper lobe by a $2\frac{1}{2}$ cm. pedicle. The lesion was excised and proved to be a fibrous mesothelioma.

cised rather simply. Clagett *et al.*³ state that, "Some of the small tumors were attached to the lung by a small vascular pedicle, and only a ligature and a few sutures were necessary to accomplish complete removal of the tumor and repair of the lung from which the tumor has orig-

inated." Except in the cases of very large tumors, the operations usually were not difficult.

A pleural fibrin ball could mimic a pedunculated pleural tumor. However, the patient's history should help in making a differential diagnosis. Fibrin balls usually

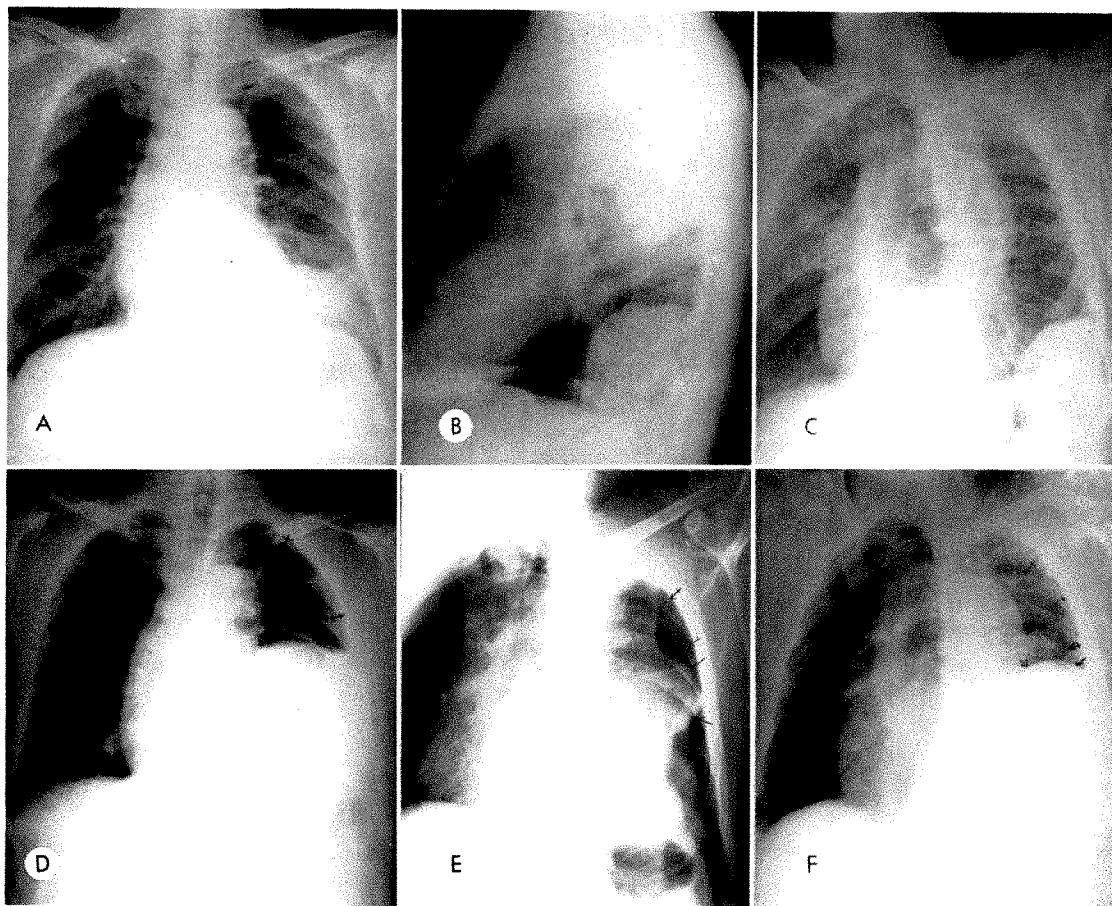


FIG. 2. A 61 year old white male was admitted because of hypertension, congestive heart failure and hemoptysis. There was an 8 year history of a left chest tumor.

(A, B and C) A 9×8 cm. shadow was present in the left posterior costophrenic sinus. Note that the abnormal density is smooth, rounded and does not obliterate the vascular shadows in the left lower lobe. (D, E and F) Following attempted needle biopsy of the mass, a hemopneumothorax developed. The margin of the left upper lobe ($\dagger$) and the mass ($\uparrow$) are clearly shown. The mass has risen from the posterior costophrenic sinus as a result of the pneumothorax and lung collapse. The pleural gas sharply outlines the tumor. The marked change in the position of the mass with respect to both lung and parietal pleura points to a lesion movable in the pleural space, *i.e.* a localized, pedunculated pleural tumor.

At thoracotomy a firm, bosselated tumor was found attached to the visceral pleura of the posterior basal segment of the left lower lobe by a $1\frac{1}{2}$ cm. pedicle. The lesion was extirpated and proved to be a fibrous mesothelioma.

occur in association with or secondary to longstanding pneumothorax, especially therapeutic pneumothorax.

SUMMARY

1. Thirty to fifty per cent of localized fibrous pleural mesotheliomas are pedunculated.

2. The roentgenologic signs of pedunculation of pleural masses are presented and two cases of localized fibrous mesothelioma demonstrating these signs are illustrated.

3. Roentgenologic analysis which shows that a peripheral intrathoracic mass is pedunculated indicates that the lesion is pleural in origin, likely a benign tumor, and probably a localized fibrous mesothelioma.

4. Pedunculation of the tumor implies that a relatively simple surgical removal is possible.

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POST-TRAUMATIC HERNIATION OF THE LUNG*

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POST-TRAUMATIC herniation of the lung is a relatively uncommon condition. Fewer than 300 cases are recorded in the medical literature to date and a review of the recent radiologic literature reveals only 1 well-documented case reported since 1940.^{3,4,10}

REPORT OF A CASE

M.H. 115-007. This was the first admission of a thirty-four year old Puerto Rican male complaining of a "lump on the chest." Approximately twelve years prior to admission, the patient, in an attempted suicide, inflicted multiple knife wounds to his left hemithorax. Other than suturing of superficial lacerations, no reparative or intrathoracic surgery was performed. Eight years prior to admission, a left parasternal bulge was noted which was markedly accentuated on coughing, sneezing and straining. This persisted unchanged to the present. No pain was experienced at any time.

Physical examination showed a relatively healthy male in no distress. Vital signs were normal. Multiple small scars were noted over the left hemithorax, anteriorly. A 2-3 cm. defect in the intercostal muscles was palpable at the level of the third anterior intercostal space medial to the costochondral junction and lateral to the sternum. On coughing or performance of the Valsalva maneuver, a large, crepitant bulge measuring approximately 5×2 cm. appeared at the site of the defect. The bulge vanished and the chest was rendered normal in appearance when quiet respirations were resumed.

Laboratory data included a normal hemogram and urogram; serology was negative. Pulmonary functions revealed a vital capacity of 3,460 cc. (92 per cent of predicted normal), maximum breathing capacity 1,080 cc. (105 per cent of predicted normal). Left brachial artery puncture; O₂ content 18.6 volume per cent, CO₂ content 18.8 mEq./L., O₂ capacity 19.7 volume per cent, O₂ saturation 94 per cent, pH 7.50, calculated partial pressure CO₂ 30 mm.

Roentgenograms of the chest in the frontal and lateral projections were normal (Fig. 1, *A* and *B*). Roentgenograms obtained during a Valsalva maneuver showed a radiolucent area, projecting beyond the confines of the thoracic cage, measuring 5×2 cm. and containing lung markings. This area was at the level of the left third anterior intercostal space in the parasternal region and was best visualized in the right anterior oblique and left lateral projections (Fig. 2, *A* and *B*). The impression was that of a parasternal herniation of the lung.

Treatment consisted of surgical repair of the muscular defect using an ivalon patch. The patient made an uneventful recovery and was discharged twelve days after surgery. Post-operative follow-up roentgenograms were not obtained.

DISCUSSION

A lung hernia may be defined as a protrusion of the lung beyond the normal confines of the thoracic cavity through an abnormal opening in the chest wall. The hernia is covered by a pleural sac and skin. Transmediastinal hernias are not related etiologically or pathologically to the hernias being considered here, and are not included.

The basic classification as suggested by Morel-Lavallée⁹ in 1847 is still accepted today.^{4,7} Table I gives the combined data, as gleaned from the literature, for all lung hernias when classified according to location. Table II gives the data when classification is by etiology.^{4,7,8}

The majority of cervical herniations are congenital or spontaneous in nature, usually due to a defect in Sibson's fascia, and occur between the scalenus anticus and sternomastoid muscles, an anatomically weak area where the lung is least protected by bone and muscle.^{2,5,11}

Most thoracic hernias follow trauma

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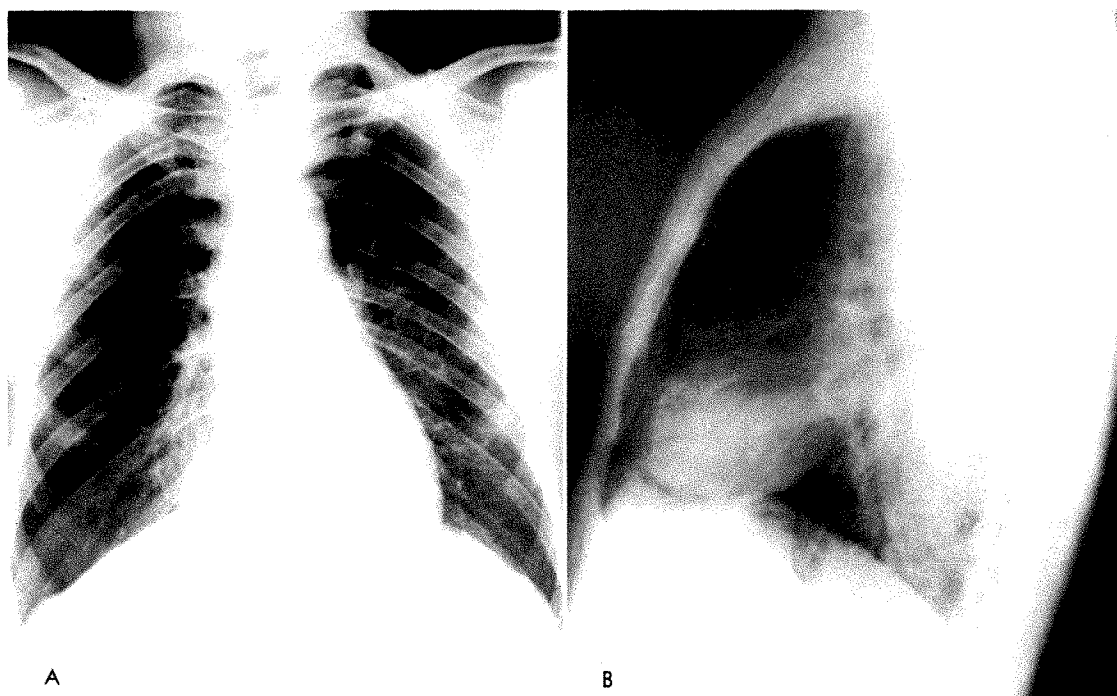


FIG. 1. (A) Posteroanterior and (B) left lateral chest roentgenograms during usual deep inspiration show no abnormality.

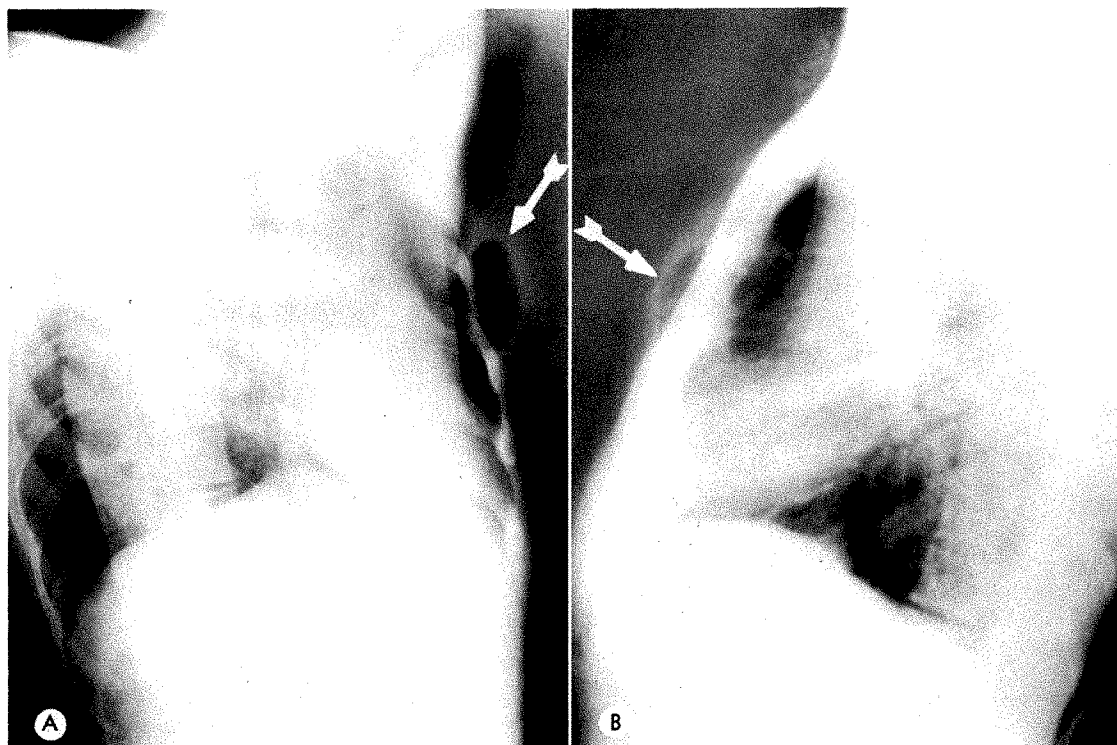


FIG. 2. (A) Right anterior oblique and (B) left lateral roentgenograms of the chest during the Valsalva maneuver demonstrate the lung hernia (arrows).

TABLE I
CLASSIFICATION OF LUNG HERNIAS
ACCORDING TO LOCATION

Location	Montgomery and Lutz ⁸		Hiscoe and Digman ⁴		Combined Figures (Per Cent)
	No. of Cases	Per Cent	No. of Cases	Per Cent	
Cervical	16	20.5	17	30.4	25
Thoracic	62	79.5	39	69.6	75

which may be of varying degrees of severity ranging from simple rib fractures to extensive operative procedures. Herniation commonly occurs at the site of previous trauma. A combination of acquired and congenital factors may operate to cause herniation at a location distant from the site of previous trauma. Anteriorly in the parasternal region just medial to the costochondral junction, where the intercostal musculature is thinnest, is the most common location for such herniation. Posteriorly, at the costovertebral angle just medial to the termination of the internal intercostal muscles, there is another site of anatomic weakness. Here, protection is afforded by the heavy paraspinal muscles making herniation less likely.

In his original classification, Morel-Lavallée⁹ included consecutive hernias in the acquired group and he defined them as hernias with delayed development after local trauma. The consecutive hernia is now included with the traumatic hernia. It

is difficult to account for the time lapse between the initial injury and the occurrence of herniation. The hernia may be secondary to a giving-way of the immediate post-traumatic fibrosis under the strain of normal and abnormal exertion.^{7,12} This feature of delayed onset characterized our case.

Today a diaphragmatic lung hernia is considered to be an impossibility because of the differential in pressures in the thoracic and abdominal cavities. In 1882, Beale¹ described 1 case of so-called incarcerated hernia of the lung through the diaphragm into the abdominal cavity. Since that time no similar cases have been reported.

Clinically, the picture is that of a relatively healthy patient who complains of a bulge in the chest occurring during coughing, sneezing and straining. The diagnosis depends on finding a soft, bulging, crepitant mass, disappearing or diminishing on rest and recurring on coughing or straining.

The roentgen examination is confirmatory. Fluoroscopy and spot roentgenography, in the oblique and lateral projections, performed while the patient is alternately at rest and straining, will satisfactorily demonstrate the to and fro movement of the lung through the hernial orifice. Roentgenograms exposed in the standard oblique and lateral projections will characteristically show a radiolucent area projecting beyond the confines of the thoracic cage and containing lung markings.

TABLE II
CLASSIFICATION OF LUNG HERNIAS ACCORDING TO ETIOLOGY

Etiology	Montgomery and Lutz ⁸		Hiscoe and Digman ⁴		Combined Figures (Per Cent)
	No. of Cases	Per Cent	No. of Cases	Per Cent	
Congenital	29	17.6	11	19.6	18
Acquired					
Traumatic	83	50.3	32	57.1	52
Spontaneous	53	32.1	11	19.6	29
Pathologic	0	0	2	3.5	1

SUMMARY

A case of post-traumatic herniation of the lung is presented with a brief review of the pathogenesis and of the present classification of lung hernias. Clinical and roentgen findings are discussed.

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THE AXILLARY MASS SIGN ON LATERAL CHEST ROENTGENOGRAMS*

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PREVIOUSLY a roentgen sign visible on certain lateral chest roentgenograms which indicates the presence of an axillary soft tissue tumor mass was described by us.¹ Since that time we have gathered additional illustrative cases, and a report of the axillary mass sign can now be made in detail.

ILLUSTRATIVE CASES

The first case which came to our attention was that of a seventy-two year old woman who was known to have had lymphosarcoma for two years, and who came to the hospital complaining of malaise and cough. Figure 1, *A* and *B* shows posteroanterior and left lateral six-foot chest roentgenograms both of which reveal an anterior superior mediastinal tumor mass. On the lateral roentgenogram, however, there is an additional density superimposed upon the upper posterior portion of the cardiac silhouette. Its curvilinear anterior margin is clearly defined but its posterior margin is not, for it fades into the general density of the hilus and posterior mediastinal area. There is no corresponding finding on the frontal roentgenogram to explain the presence of a possible second mediastinal mass. The shadow in question was uneasily interpreted as due to some unusual soft tissue fold or a processing artefact.

Further roentgen study was performed after a course of radiation therapy, a tumor dose of 2,500 rads being delivered through opposing ports to the superior mediastinum (Fig. 2, *A* and *B*). The upper mediastinal tumor mass had regressed, but again a mass shadow was present on the lateral roentgenogram, obviously representing neither a tumor within the chest

nor an artefact. We examined the patient and found a voluminous, soft right axillary mass which was said to have been residual following a course of radiation therapy delivered to enlarged right axillary lymph nodes at another hospital two years before. On inspection and palpation of the axilla with the patient positioned as for lateral chest roentgenography, it could be seen that the anterior margin of the mass was sharply defined and projected well above the surface of surrounding axillary contents; posteriorly the mass disappeared under the dorsal muscle groups. The clear anterior margin seen on the roentgenograms was not, as we at first suspected, the result of compression of the pliable mass against the cassette holder, for it was equally well delineated on both left and right lateral roentgenograms (Fig. 1, *A* and *B*; and 2, *A* and *B*).

In order to prove beyond doubt that the shadow in question really represented a right axillary mass, we asked the patient to cooperate with us in one last test: the surface of the mass was liberally painted with an iodine-containing roentgenographic contrast material and roentgenograms were taken in the posteroanterior and in both lateral projections (Fig. 3, *A*, *B* and *C*). The mass was readily identifiable in the frontal projection (Fig. 3, *A*) and was obviously responsible for the rounded soft tissue density seen on earlier studies (Fig. 3, *B* and *C*).

Unless emergency circumstances dictate otherwise, six-foot posteroanterior and left lateral chest roentgenograms are the routine procedure for chest studies used in this department, and so, on the lateral chest roentgenograms of a number of patients from the tumor services, we have had addi-

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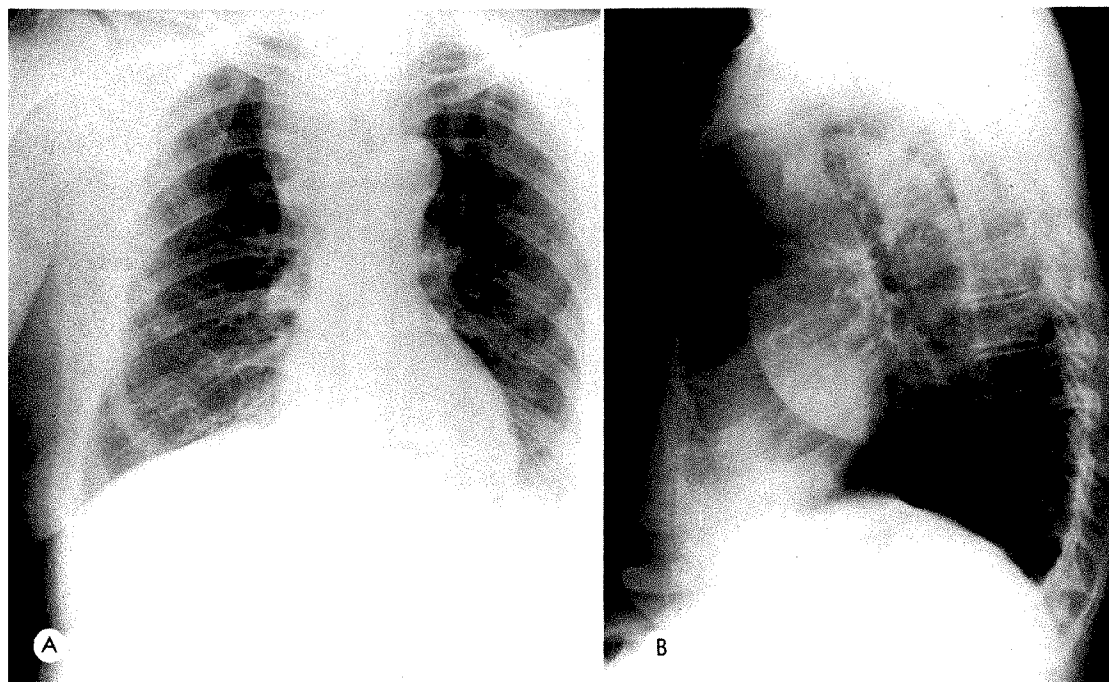


FIG. 1. (A) Posteroanterior and (B) left lateral chest roentgenograms show a right anterosuperior mediastinal mass in a patient with known lymphosarcoma. A sharp curvilinear margin superimposed upon the cardiac silhouette on B suggests the presence of an intrathoracic mass which is not visible on the frontal roentgenogram.

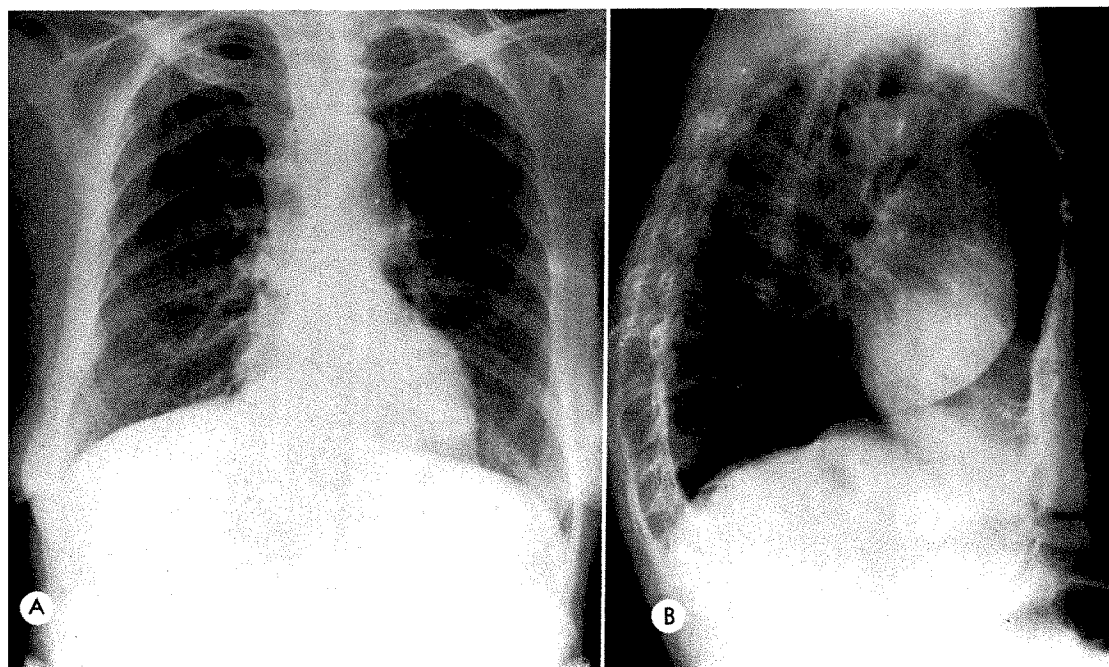


FIG. 2. Same patient as in Figure 1. (A) Posteroanterior and (B) right lateral roentgenograms made after a course of radiation therapy to the superior mediastinum. The tumor mass has disappeared (A), but a mass shadow (B) again overlies the cardiac silhouette; this time in a more anterior and somewhat lower position.

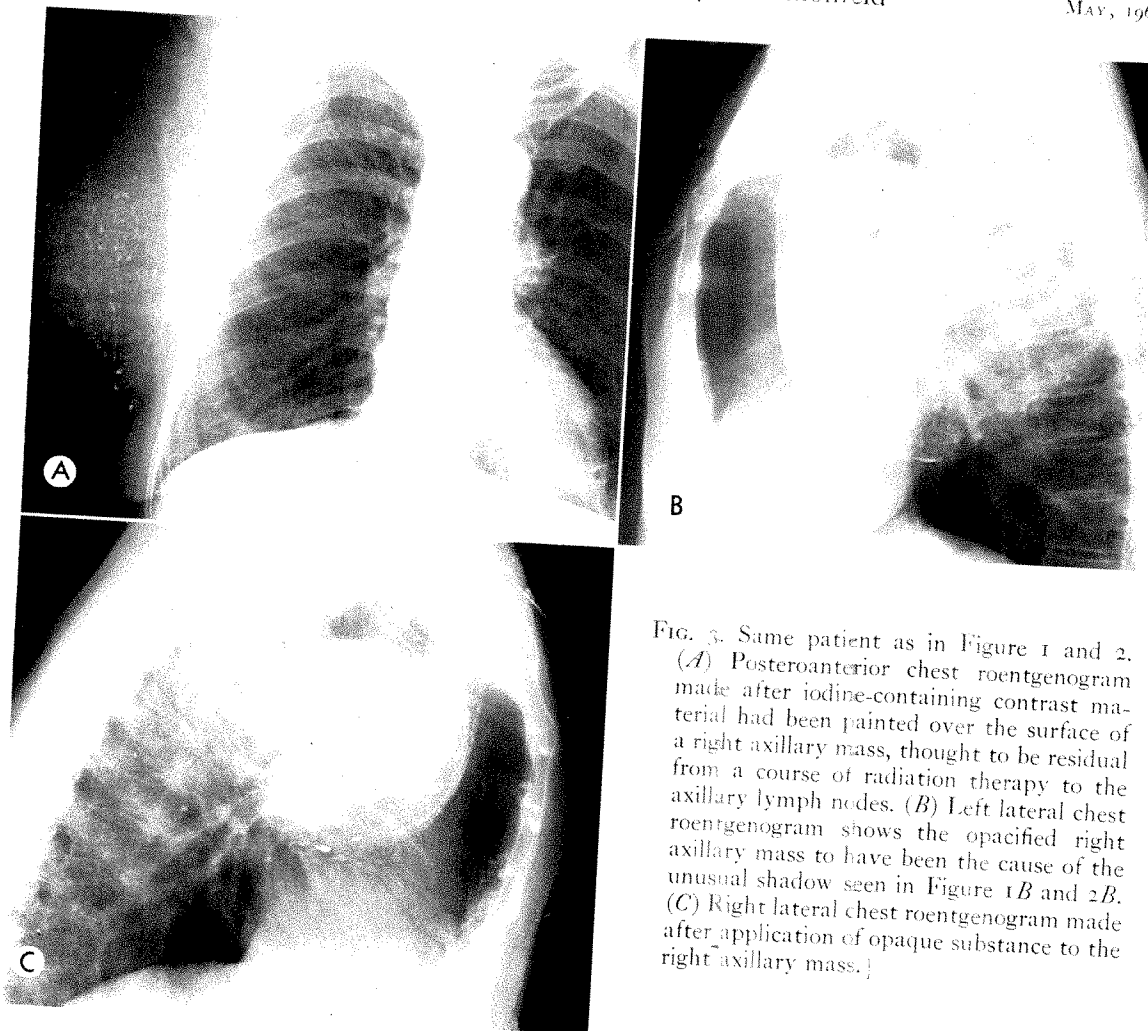


FIG. 3. Same patient as in Figure 1 and 2. (A) Posteroanterior chest roentgenogram made after iodine-containing contrast material had been painted over the surface of a right axillary mass, thought to be residual from a course of radiation therapy to the axillary lymph nodes. (B) Left lateral chest roentgenogram shows the opacified right axillary mass to have been the cause of the unusual shadow seen in Figure 1B and 2B. (C) Right lateral chest roentgenogram made after application of opaque substance to the right axillary mass.]

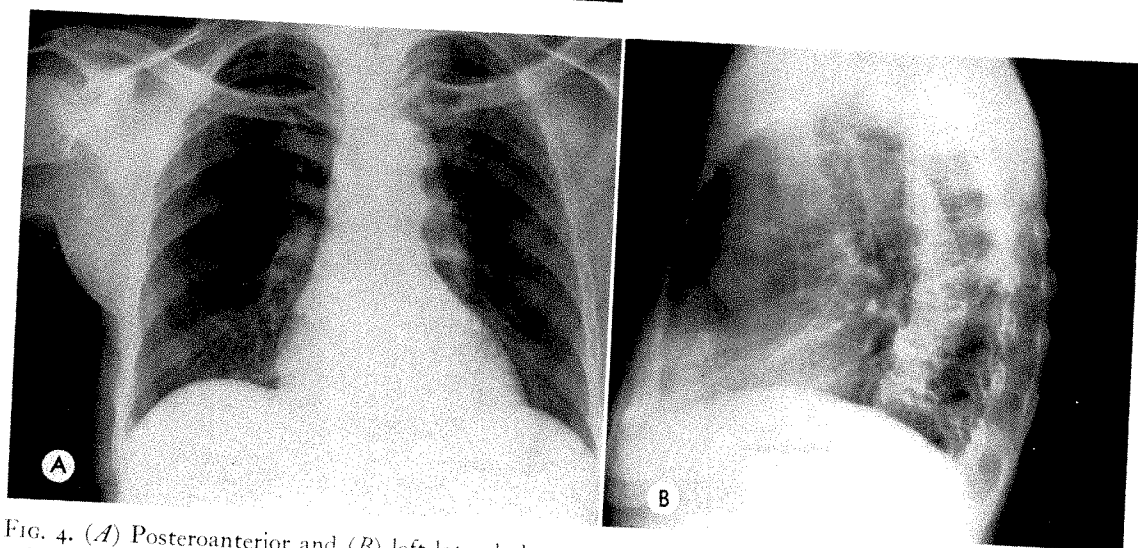


FIG. 4. (A) Posteroanterior and (B) left lateral chest roentgenograms of a sixty-five year old woman with known chronic lymphocytic leukemia. A shows evidence of clinically obvious right upper axillary lymph node mass. Note sharply defined, curvilinear anterior border presenting in anterior mediastinal region on B and the absence of a true mediastinal mass on A.

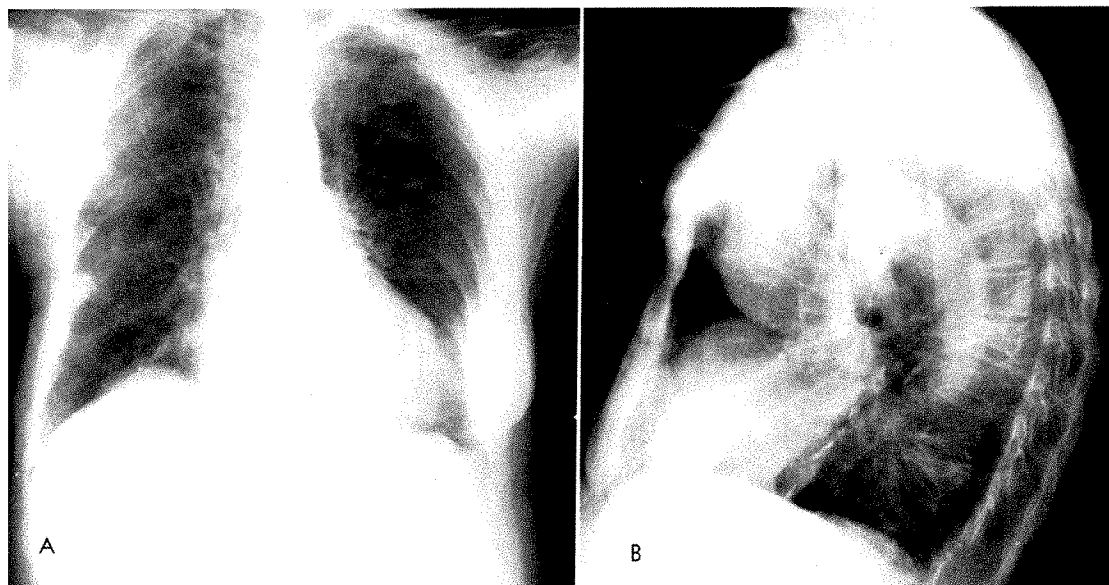


FIG. 5. (A) Posteroanterior and (B) left lateral chest roentgenograms of a seventy-nine year old woman with widespread metastases from an adenocarcinoma of the right breast. The right axillary mass is visible on A and the axillary mass shadow is visible in the anterior mediastinum on B, showing a sharply defined, curved anterior border, fading off posteriorly into the midmediastinal structures. This density is the characteristic appearance of upper axillary masses on lateral chest roentgenograms. Both A and B show considerable evidence of bone metastasis. Patient motion occurred during exposure of A.

ional opportunity to observe this aspect of axillary soft tissue tumor masses.

Figure 4, A and B shows the initial roentgenograms of a sixty-five year old woman who had developed generalized lymphadenopathy in the course of chronic lymphocytic leukemia. She had a large upper right axillary lymph node mass which was easily seen on the frontal projection (Fig. 4A) and caused the mass shadow seen on the lateral chest roentgenogram (Fig. 4B) in the anterior mediastinal region.

Another example of an axillary mass which simulates a mediastinal tumor on the lateral chest roentgenogram is seen in Figure 5B, which was made under emergency circumstances of a seventy-nine year old woman known to have an adenocarcinoma of the right breast. In addition to numerous metastases to lung, ribs and thoracic vertebrae, the lateral roentgenogram shows an anteriorly rounded density superimposing the superior mediastinal region. There was no evidence of the presence of an intrathoracic mass on the frontal projection (Fig. 5A); however, there

was evidence of an irregular lymph node mass high in the right axilla, the true cause of the mass shadow visualized on the lateral roentgenogram.

The appearance of bilateral axillary masses is demonstrated on Figure 6, A and B, the posteroanterior and left lateral chest roentgenograms of a seventy-two year old man who had chronic lymphocytic leukemia. The more anterior of the two mass shadows on the lateral roentgenogram is readily recognizable as being extramural, for its upper margin crosses the sternum. The more posterior mass, however, seems to lie within the thorax.

When both axillary and hilar masses are present, interesting findings appear on the lateral roentgenogram. Figure 7, A and B shows the initial roentgenograms of a sixty-five year old man known to have chronic lymphocytic leukemia. A relatively flat but sizable right upper axillary mass was apparent on physical examination and can be seen on the posteroanterior roentgenogram (Fig. 7A). The lateral roentgenogram (Fig. 7B) shows the axillary mass shadow

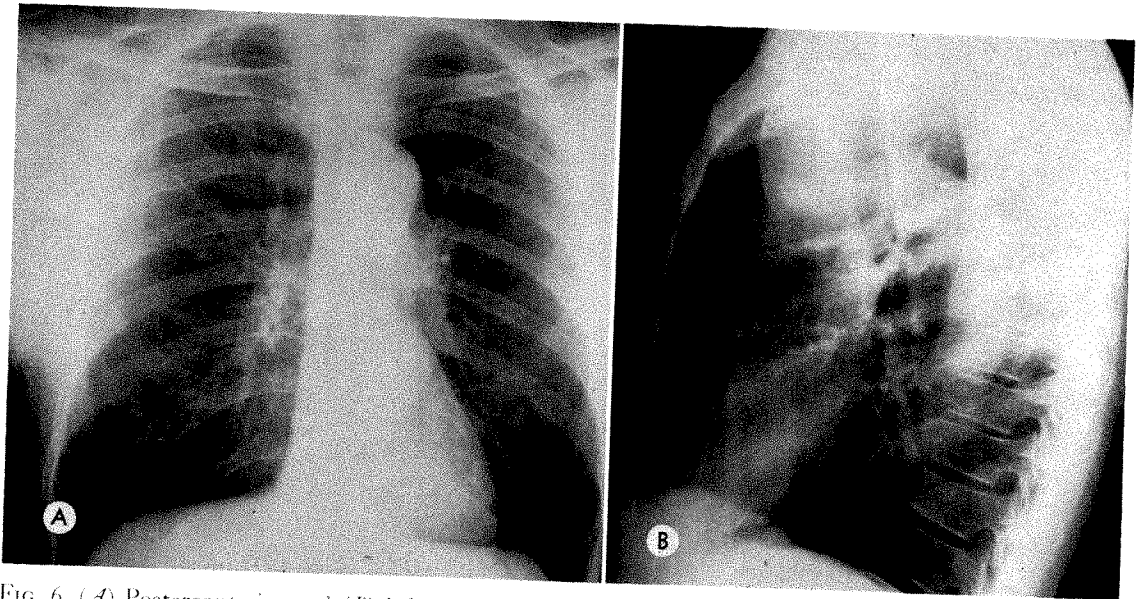


FIG. 6. (A) Posteroanterior and (B) left lateral chest roentgenograms of a seventy-two year old man with chronic lymphocytic leukemia. Bilateral upper axillary masses were present, and the one on the right can be detected on A. B shows two axillary mass shadows. The larger and more anterior one is obviously extramural in origin for its curved anterior border crosses the upper sternum. The second and smaller mass shadow seems to lie wholly within the thorax, and simulates a mediastinal mass not identifiable on A.

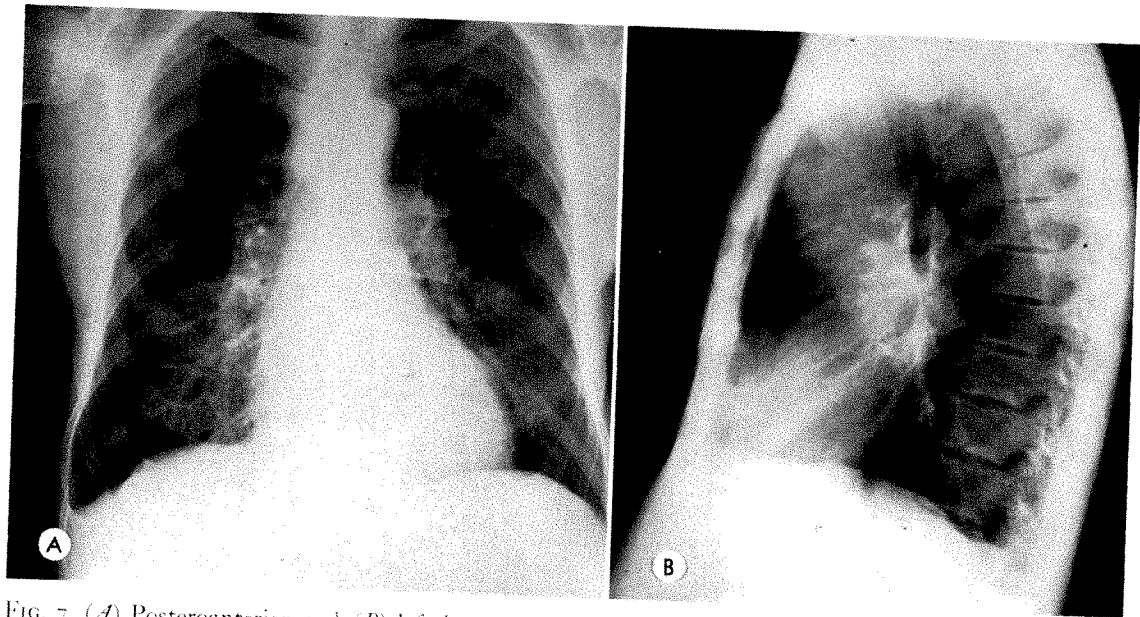


FIG. 7. (A) Posteroanterior and (B) left lateral chest roentgenograms of a sixty-five year old man known to have chronic lymphocytic leukemia. Physical examination showed a right upper axillary lymph node mass which is visualized on A. Bilateral hilar lymphadenopathy is present as is a small right pleural effusion. Note the unusual shadow on B which is a composite of the axillary mass (upper portion) and the superimposed left and right hilar lymphadenopathy (lower portion).

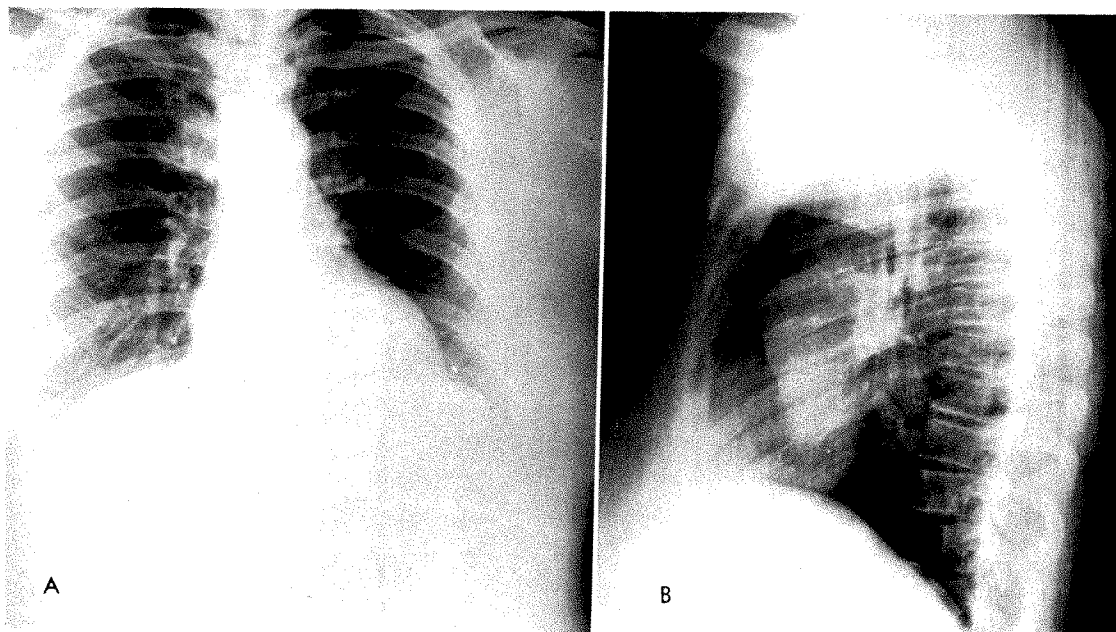


FIG. 8. (A) Posteroanterior and (B) left lateral chest roentgenograms of a sixty-year old woman. A processing artefact in the right suprahilar area is seen on A. Note the relatively straight but well defined density superimposing the cardiac silhouette and anterior mediastinum on B. This is the shadow of a heavy anterior axillary fold.

with its well-defined anterior border presenting in the anterior superior mediastinum. The axillary tumor density extends posteriorly and downward into the composite hilar mass shadow produced by the moderate bilateral hilar lymphadenopathy.

Thus, part of the mass shadow visualized on the lateral chest roentgenogram is intrathoracic in origin, and part is not.

Occasionally, heavy anterior axillary folds in obese persons cause shadows which simulate the axillary mass sign. These usu-

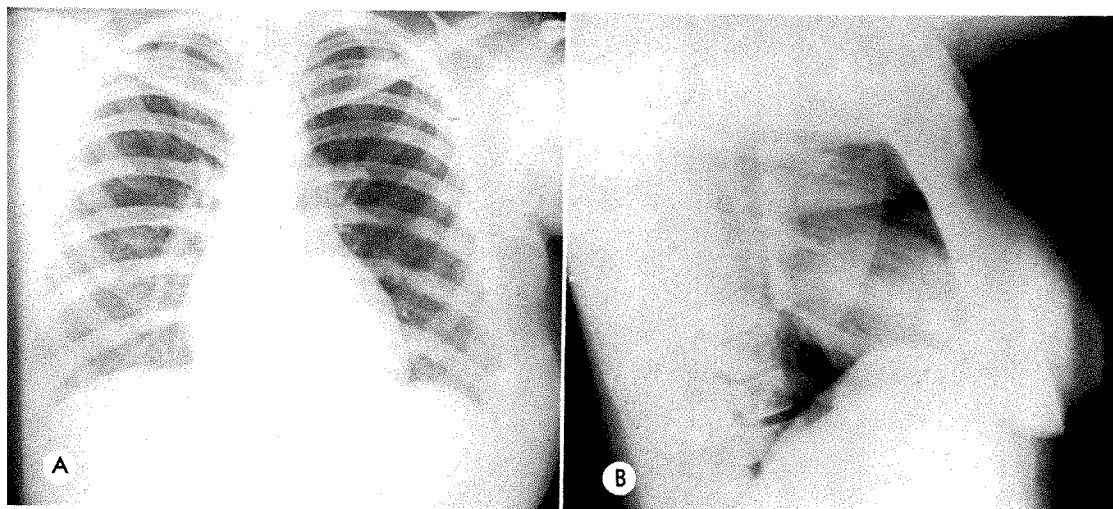


FIG. 9. (A) Posteroanterior and (B) right lateral chest roentgenograms of a forty-five year old woman show a configuration much akin to that caused by the presence of a lower axillary mass. Physical examination of the patient revealed no axillary mass, only heavy anterior axillary folds in an obese patient.

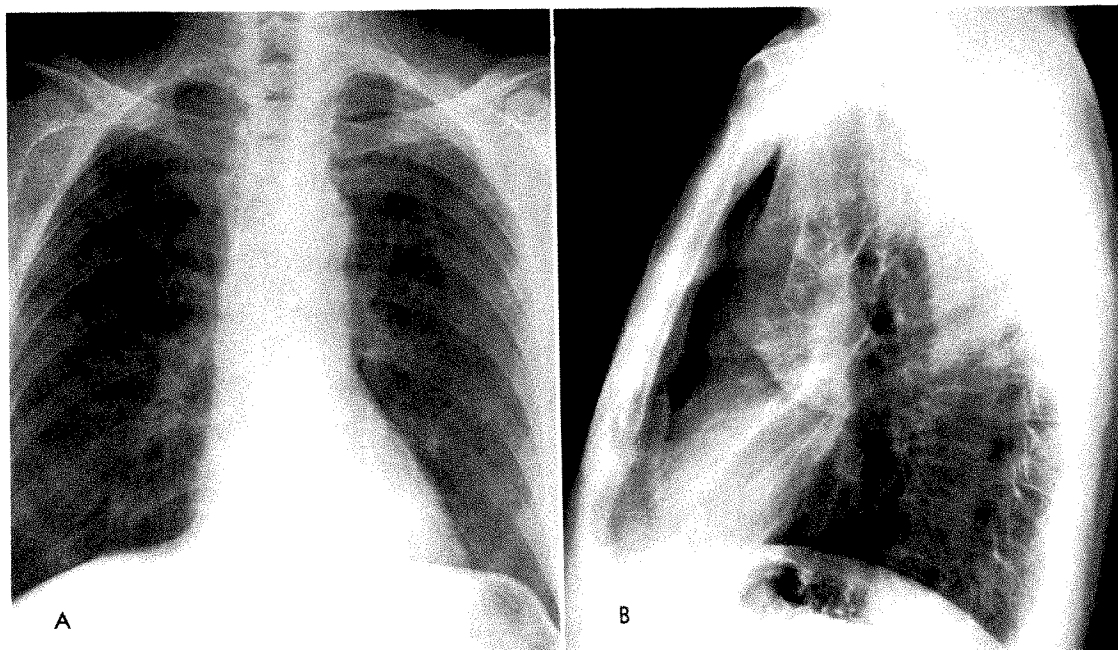


FIG. 10. (*A*) Posteroanterior and (*B*) left lateral chest roentgenograms of a seventy year old man. *B* shows an irregularly rounded mass shadow superimposing the upper lung fields, identifiable as an amputation stump of the right arm by the presence of a demineralized humerus within it.

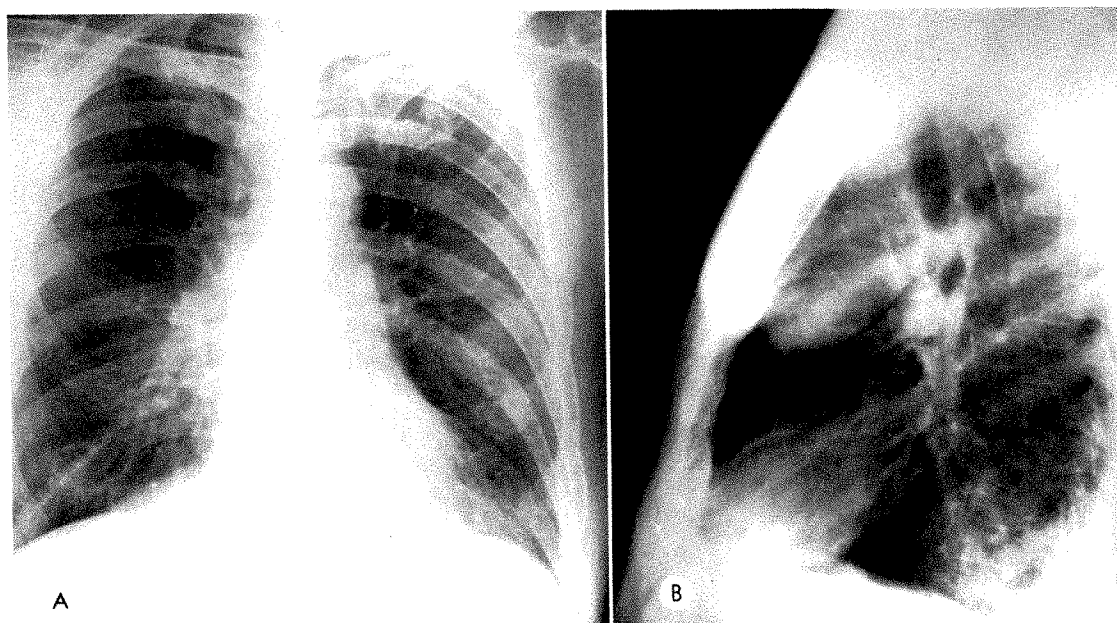


FIG. 11. (*A*) Posteroanterior and (*B*) left lateral chest roentgenograms of a sixty-nine year old man. Mass shadow, due to an amputation stump of the left arm, is somewhat harder to diagnose, for the humerus is superimposed upon the upper sternum.

ally present the appearance seen on Figure 8, *A* and *B* in which the anterior margin of the axillary fold is relatively straight, but, on occasion, a re-examination is necessary so as to be sure that an axillary mass was indeed not present (Fig. 9, *A* and *B*).

Under certain circumstances the false axillary mass visualized on the lateral chest roentgenogram may itself be simulated by an extrathoracic and extra-axillary structure: *i.e.*, the stump of an amputated arm. Figure 10, *A* and *B* shows such a stump, readily identifiable because of the presence of a demineralized proximal humerus. The findings on Figure 11, *A* and *B* are somewhat more subtle, however, with the only visible portion of the humeral stump superimposed upon the sternum, and with the soft tissues of the stump simulating a lesion of unusual location.

Recognition of the axillary mass sign will occur frequently as the routine use of the lateral chest roentgenogram becomes more widespread. The origin of this mass shadow, although sometimes apparent on frontal and lateral roentgenograms is often perplexing, requiring the radiologist to perform a physical examination of the axilla

and its environs in a truly clinical manner.

SUMMARY AND CONCLUSIONS

1. Axillary soft tissue tumor masses may simulate mediastinal tumors on lateral chest roentgenograms, usually presenting in the anterior superior or middle mediastinum with well-defined curvilinear anterior margins. A tumor of appreciable size in one axilla will cause such a shadow on either lateral chest roentgenogram.

2. The axillary mass sign on lateral chest roentgenograms may itself be simulated by heavy anterior axillary folds in obese persons. As a rule, fold lines are straighter in contour and lower in position than the usual axillary mass shadow.

3. Other structures, such as the stumps of amputated arms, may simulate both axillary and true intrathoracic mass shadows.

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CALCIFIED PULMONARY ARTERY THROMBUS*

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THE purpose of this paper is to report a proved case of calcified pulmonary artery thrombus demonstrated roentgenographically. Attention has not been specifically directed to the recognition of the calcification on chest roentgenograms; however, we feel that more cases will probably be diagnosed as radiologists become aware of this entity. The following reasons substantiate this belief: (1) it is well known both clinically and experimentally that a thrombus in any vessel in the body, especially if present for a long time, may calcify; also, it has been well documented that thrombosis of a major pulmonary vessel may be compatible with long survival;⁶⁻⁹ therefore, it would seem logical to expect these thrombi, on occasion, to calcify; (2) there are references to branching intrapulmonary calcifications which do not have pathologic verification but could represent calcified thrombi;⁵ and (3), most significantly, there has been adequate pathologic documentation of calcification in pulmonary artery thrombi.

REPORT OF A CASE

F.A., a sixty-seven year old Negro female, entered Cincinnati General Hospital because of the sudden onset of left-sided paralysis. She had had a bout of congestive heart failure one year prior to admission. Thirty years prior to admission there occurred an acute attack of severe chest pain following a pelvic operation. This may well have represented the original episode of pulmonary embolism.

On physical examination the only pertinent finding was that of hypertension and left hemiplegia. Laboratory findings were normal except for a diabetic glucose tolerance curve. The electrocardiogram showed an old anteroseptal myocardial infarction.

The admission chest roentgenogram revealed moderate cardiomegaly with normal lung fields.

The striking feature, however, was a cylindrical, branching V-shaped calcification in the right hilar area (Fig. 1 and 2). From its location and appearance it was recognized as calcification within a thrombus in the pulmonary artery.

The patient improved clinically over the next few months. However, three months later she sustained another cerebral vascular accident and was admitted to Daniel Drake Hospital, where a chest roentgenogram disclosed the same findings. The patient's condition rapidly deteriorated and she expired four days later.

At necropsy, there was thalamic infarction, coronary atherosclerosis and an old myocardial infarction. In the right main pulmonary artery, extending into the upper lobe branch, an adherent calcified thrombus was found. This thrombus was V-shaped, each arm of the V measuring 4 cm. in length and 1 cm. in diameter. It exactly conformed to the density seen roentgenographically. There was a large infarct in the right upper lobe resulting from a fresh thrombus distal to the calcified thrombus.

DISCUSSION

Pulmonary artery thrombosis may result in infarction of all or only a portion of the pulmonary parenchyma supplied by the affected vessel. However, it is not the purpose of this paper to consider the manifestations of pulmonary infarction. It is the cases with extensive thrombosis but without evidence of infarction that the radiologist finds most difficult to recognize. The diagnostic changes which one may encounter with major pulmonary artery thrombosis have been described.^{3,4,10,12} These include the following: (1) decrease in vascularity and resulting increase in radiolucency of the area supplied by the thrombosed vessel; (2) increase in the size of the involved major branch of the pulmonary artery, with abrupt diminution or "cut-off" of this vessel peripheral to the thrombus; (3) secondary enlargement of

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the right heart and dilatation of the hilar vessels; (4) decrease or absence of pulsations in the involved vessel at fluoroscopy; and (5) decrease in the size of the affected hemithorax, with crowding of the ribs. This last sign also has received little attention but we have seen 2 cases in which it occurred.

This report adds a rare but pathognomonic roentgen sign of pulmonary artery thrombosis, *i.e.*, the presence of a cylindrical calcification in the area of a major pulmonary artery. In our case this was the *only* recognizable sign of pulmonary thrombosis.

The presence of a branching cylindrical calcification, as in our case, offers little difficulty in differential diagnosis. If unbranched, or not cylindrical, thrombus calcification would be difficult to identify. Tracheobronchial calcification, as it occurs in the elderly, produces regularly spaced ring-like shadows which conform to the air-filled trachea and larger bronchi. Hilar lymph node calcifications are round or irregular and rarely, if ever, cylindrical in configuration. They do not remain within the shadows of the pulmonary arteries in

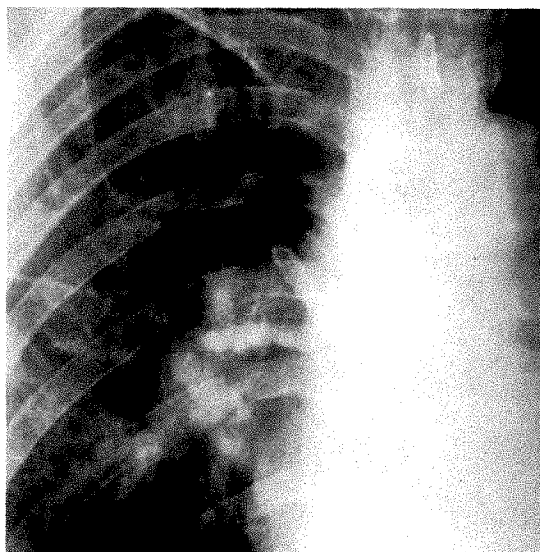


FIG. 2. An enlargement of the right hilar area showing the calcified pulmonary artery thrombus to better advantage.

multiple projections. Calcification in atheromatous intimal plaques should not be confused with the intraluminal calcification of thrombosis.¹¹ The condition of osteopathia pulmonis² produces a fine, branching intrapulmonary calcification, totally unlike the lesion under discussion. Calcification in mediastinal masses should present no problem in the differential diagnosis. If doubt exists as to the nature and location of the calcification, laminagraphy or angiography should be confirmatory.⁸

SUMMARY

A proved case of calcified pulmonary artery thrombus demonstrated roentgenologically has been presented. The roentgen manifestations of major pulmonary artery thrombosis have been enumerated and the pathognomonic sign of calcification within the thrombus has been added.

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ADDENDUM

An unreported case with a large solid oval calcification in a thrombus in the left

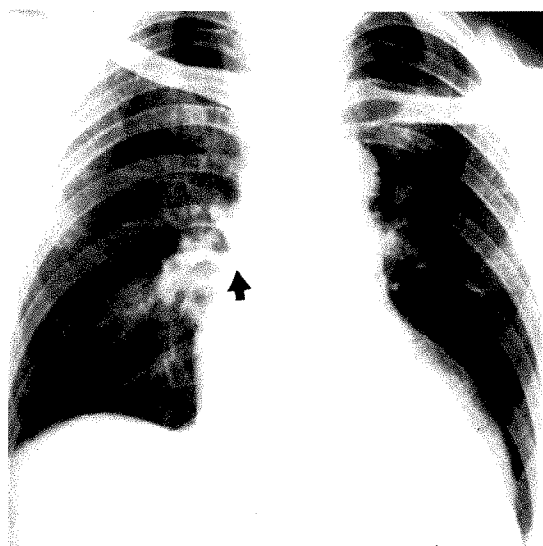


FIG. 1. Chest roentgenogram on which a V-shaped calcification (arrow) is demonstrated in the right hilar area along with blunting of the right costophrenic angle. Cardiac enlargement is also present.

pulmonary artery, confirmed at autopsy, has been encountered by Dr. Frederick J. Bonte, Parkland Memorial Hospital, Dallas, Texas.

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THE CINEFLUOROGRAPHIC APPROACH TO THE DIAGNOSIS OF PERICARDIAL EFFUSION*

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TORRANCE⁴ and Kremens³ have shown that pericardial effusion can be recognized if the apical epicardial fat line along the left border of the heart lies more than 2 mm. inside the border of the left cardiac silhouette (Fig. 1, *A* and *B*). A laminagraphic technique is generally used to identify this fat line. Unfortunately, this line is not often seen by this technique because of several factors, including the rapid movement of the fat line.

During the last four years we have found that cinefluorography lends itself very readily to the study of pulsating fat lines about the heart, and, therefore, it is our method of choice for recording fat lines. One or more fat lines usually are recognized on a cardiac cinefluorogram. The purpose of this presentation is to describe the position of these fat lines, the cinefluorographic technique for detecting them, and their use in the recognition of pericardial effusion.

ANATOMY OF THE EPICARDIAL FAT

The epicardial fat deposit, located in a layer of fibroelastic connective tissue between the ventricular musculature and the serous membrane of the visceral pericardium, varies considerably in thickness. In obese individuals it may be 2 cm. thick in the atrioventricular groove between the right atrium and the right ventricle and between the left atrium and the left ventricle. In addition, fat is deposited in the interventricular groove between the right ventricle and the left ventricle along the inferior margin of the heart and over the apex of the heart. Fat deposits about the base of the aorta and the pulmonary artery

and over the right ventricle are also common.

IDENTIFICATION OF FAT LINES BY CINEFLUOROGRAPHY

Epicardial fat appears as thin, radiolucent lines. Our method of examining the fat lines cinefluorographically requires six film sequences of the heart and great vessels.² In the posteroanterior view the only fat line commonly seen is at the apex of the heart (Fig. 2). In a normal heart the apical fat line is almost impossible to distinguish from the triangular fat pad¹ which lies between the parietal pericardium, pleura and diaphragm. A thickened pericardium, appearing as a white line, aids in separating these two fat deposits. The patient then is examined in a 45 degree right anterior oblique position (Fig. 3). In this view three fat lines can be distinguished. The fat in the atrioventricular groove forms a U-shaped curve around the inferior margin of the heart. The anterior limb contains the right coronary artery, and the posterior limb contains the circumflex branch of the left coronary artery. Between the left auricular appendage and the left ventricle, another fat line may be seen through which runs the left coronary artery. In the left anterior oblique position, the fat line in the atrioventricular groove between the right atrium and the right ventricle and the fat line between the left atrial appendage and the left ventricle can be cinefluorographed (Fig. 4). Finally, in the left lateral view, two and occasionally three fat lines can be seen (Fig. 5). In this view the fat line in the atrioventricular groove between

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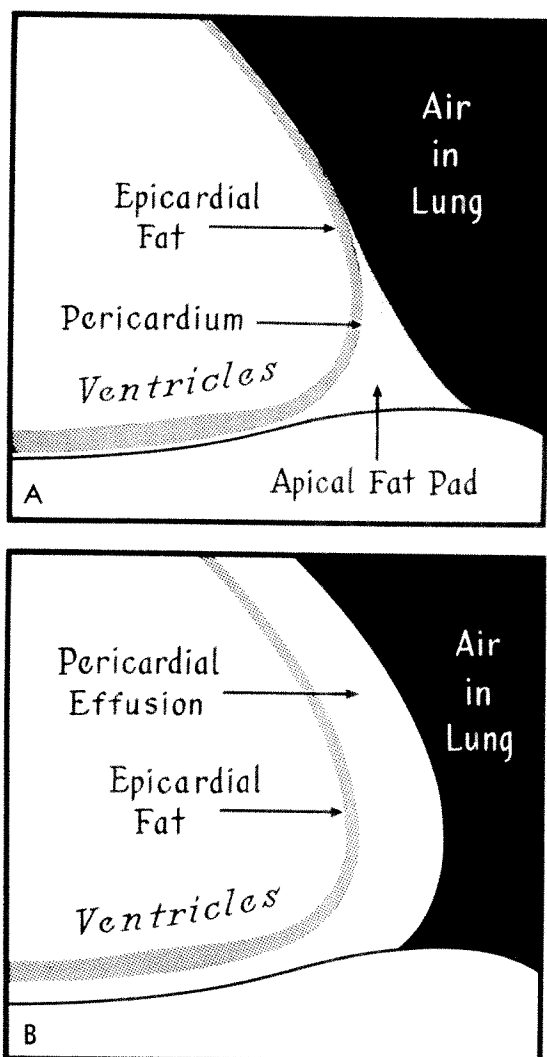


FIG. 1. (A) Normal apical structures. (B) The apical epicardial fat line is 2 mm. or more within the outer left cardiac silhouette in the presence of pericardial effusion.

the right atrium and the right ventricle can be identified. Also, the line between the left atrium and the left ventricle is usually recorded; this merges with the horizontal fat line containing the anterior descending branch of the left coronary artery and continues in the interventricular groove over the anterior surface of the heart. The third line is prominent when accompanied by pericardial effusion or a thickened pericardium, but otherwise it is difficult to detect.

METHOD OF CHOICE

Cinefluorography is the method of choice for detecting and recording epicardial fat lines of the heart because one or more fat lines are demonstrated on almost every routine cardiac cinefluorogram.

Before cinefluorography, the epicardial fat line could be seen in only a limited number of cases because the rapidly moving fat line was blurred on the relatively long exposed roentgenogram or laminagram.

By cinefluorography the rapidly moving apical radiolucent line can be easily recorded, especially if the fat lines are surrounded by thickened pleuropericardium or pericardial effusion. The pericardial effusion emphasizes the fat lines due to the sharp change in the density between the fat deposits and the effusion⁵ (Fig. 6, A and B).

THE CINEFLUOROGRAPHIC SIGNS OF PERICARDIAL EFFUSION

The cinefluorographic signs of pericardial effusion are: (1) a decreased amplitude of pulsation of the pleuropericardial border; (2) prominent fat lines about the heart; and (3) an increase in the distance between the

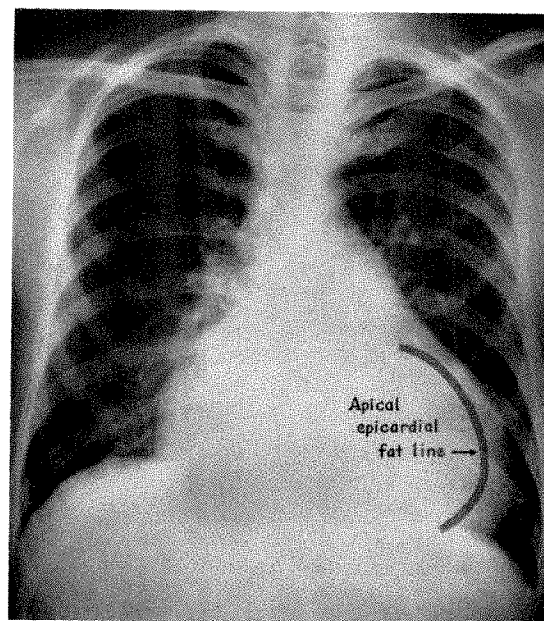


FIG. 2. Posteroanterior view. In the presence of pericardial effusion the fat line is more prominent than in the normal.

fat line and the pleuropericardial border.

A diagnosis of pericardial effusion was made cinefluorographically in 13 of the 2,000 patients examined at the Minneapolis Veterans Administration Hospital. Of these 13 patients, 7 underwent a pericardiocentesis, which proved the presence of a pericardial effusion in 6 of them. One patient had no demonstrable pericardial effusion on a single pericardiocentesis. In all 7 of these patients the clinician suspected the presence of pericardial effusion and the cinefluorographic examination provided confirmatory evidence. Two of the 13 patients were autopsied; one showed Hodgkin's tumor invading the pericardium, and another showed carcinoma invading the pericardium. The other 4 patients had clinical findings strongly suggestive of pericardial effusion.

The entire heart border pulsation was either noticeably diminished in amplitude or completely absent in 5 of the 6 patients with pericardial effusion. It seems probable that adhesions between the visceral and parietal pericardium were present and these were able to move the pleuroperi-

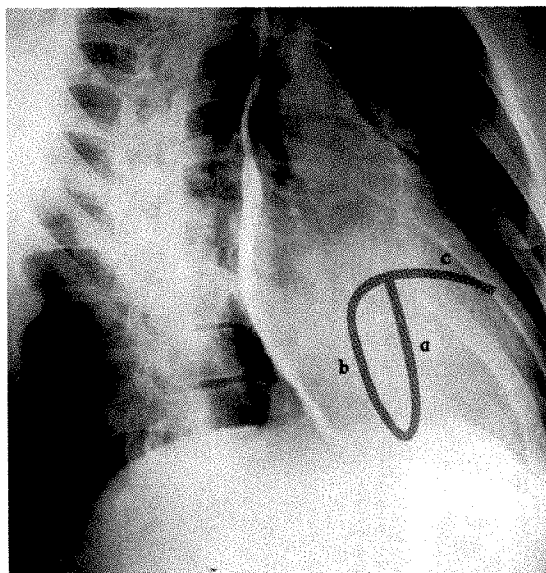


FIG. 3. Right anterior oblique view showing (a) the anterior limb, (b) the posterior limb of the atrioventricular fat line and (c) the fat line between the left atrial appendage and the left ventricle.

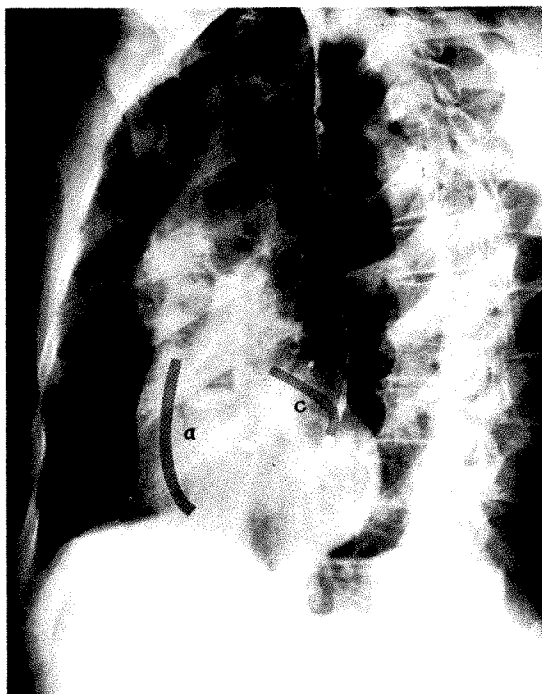


FIG. 4. Left anterior oblique view showing (a) the anterior limb and (c) the fat line between the left atrial appendage and the left ventricle.

cardial border simultaneously with the myocardial pulsation even though the epicardium and parietal pericardium were separated by pericardial effusion.

Four of the 6 patients, having a proven pericardial effusion, showed an apical epicardial fat line in the posteroanterior view, and the anterior portion of the inter-ventricular fat line in the left lateral view. All 6 patients showed the atrioventricular fat line in the left and right anterior oblique views. The atrioventricular line, therefore, is the fat line most likely to be detected. Normally, the apical fat line is less than 2 mm. from the left lateral border of the heart. In 4 of these 6 patients the apical fat line was 1 cm. or more from the outer border of the heart, suggesting strongly the presence of pericardial effusion.

In the normal, the amplitude of pulsation of the outer pleuropericardial border duplicates the amplitude of the fat lines. In the presence of pericardial effusion, however, the movement of the fat lines

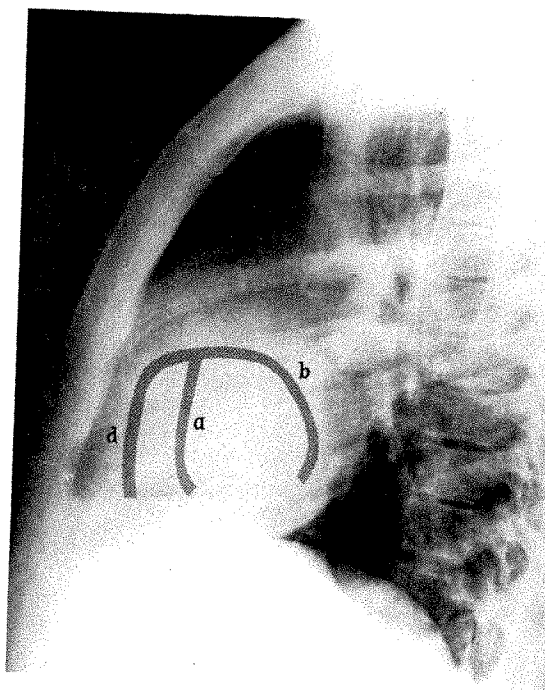


FIG. 5. Left lateral view showing (a) the anterior limb and (b) the posterior limb of the atrioventricular fat line. The interventricular fat line (d) is not usually seen unless forced away from the sternum by pericardial effusion.

is relatively more vigorous than that of the pleuropericardial border because the myocardial pulsation which is usually transmitted to the outer border is dampened by the interposing pericardial effusion. If the amplitude of pulsation of the epicardial fat line is decreased, the presence of a cardiac tamponade or myocardial damage should be suspected.

If the apical epicardial fat line is absent, the atrioventricular fat line in the left anterior oblique view is obvious in patients with pericardial effusion. If effusion is absent, the fat line is less prominent. A decrease in the prominence was noted in one of our patients who was re-examined after the resorption of the pericardial effusion.

In the left anterior oblique view, the amplitude of pulsation of the pleuropericardium over the right atrium also is decreased relative to the amplitude of the atrioventricular fat line in the presence of pericardial effusion. No normal standard of distance from the atrioventricular fat line

to the outer pleuropericardial border of the right cardiac silhouette has been established, so the criterion of distance must be evaluated subjectively in this view.

Similarly, in the right lateral view, the fat over the anterior border of the heart is noticeable when pericardial effusion is present. Pericardial effusion collects in the anterior portion of the pericardial sac, forcing the heart and its accompanying fat line posteriorly away from the sternum so that it can be readily visualized.

It is not known how much pericardial effusion is necessary to dampen the pulsation of the outer cardiac silhouette. During

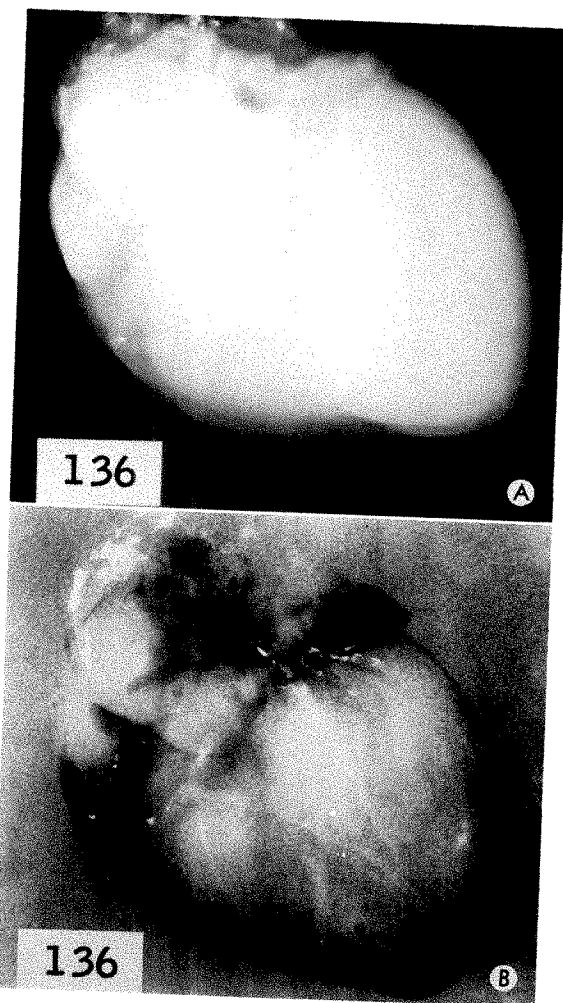


FIG. 6. (A) Roentgenogram of a heart in air. (B) The same heart immersed in water, causing the fat to stand out as a black line.

an attempt to inject hypaque into the left ventricle, 35 cc. was injected by mistake into the pericardial sac of a patient. A cinefluorogram, taken within three minutes, showed an absence of movement of the outer cardiac silhouette over both the right and left heart borders. The hypaque formed a thin rim about the pulsating epicardium and the base of the great vessels in the recumbent position. The hypaque did not appear to be diluted. From this single incident, it appears that only a few cubic centimeters of fluid will dampen the pulsations transmitted to the outer cardiac silhouette if pericardial adhesions are not present.

THE ADVANTAGES OF THE CINEFLUOROGRAPHIC METHOD

Fat lines are difficult to recognize by conventional fluoroscopy unless the fat deposits are thick. Detection of fat lines by image amplification, on the other hand, is easy and is almost as reliable a method as cinefluorography.

The advantages of cinefluorography are several. First, fat lines other than the apical fat line can be recognized and used in the diagnosis of pericardial effusion. The atrioventricular fat line is the most constant line and the most useful if the apical fat line is absent. This line, however, is difficult to detect by conventional roentgenography and easy to recognize by cinefluorography. Secondly, cinefluorography can be performed quickly and repeatedly similar to conventional fluoroscopy in either the recumbent or erect position. In the very sick patient, the ease of the cinefluorographic examination in contrast to the somewhat more difficult carbon dioxide method is important.

THE LIMITATIONS OF THE CINEFLUOROGRAPHIC METHOD

The cinefluorographic method based on the presence of fat lines has real limitations. First, a certain quantity of normal fat must be present in the epicardium to be recognizable. Apical fat lines cannot be

detected in every patient with pericardial effusion because of several factors, the most important being the amount of epicardial fat present and the thickness and density of the patient's thorax and heart. Four of the 6 patients (67 per cent) with pericardial effusion had an apical epicardial fat line plainly visible on cinefluorograms. This percentage is in accord with our autopsy observations. No apical fat could be found in 8 out of 100 hearts inspected at successive autopsies. In 29 of the 100 hearts, the apical fat was 2 mm. or less in thickness and would be difficult to detect on the cinefluorogram. Thus the apical epicardial fat line is of value in detecting pericardial effusion in approximately 60 to 70 per cent of patients. In those patients without an apical fat line, other fat lines about the heart can be used for the detection of pericardial effusion. But again, about 5 per cent of all patients will not have sufficient fat to be detectable even in the most constant area, the atrioventricular groove. In these patients the carbon dioxide method which is not based on the presence of fat lines is better.

The second limitation of importance is the subjective evaluation of the amplitude of pulsation of both the pleuropericardial border and the fat line and the subjective evaluation of the prominence of the fat line. The accuracy of this evaluation is dependent mainly upon the experience of the cinefluorographer. Difficulty in the differential diagnosis between pleuropericardial thickening and pericardial effusion will be encountered usually during a resolution state of pericardial effusion.

Both pericardial thickening and pericardial effusion will cause the fat line to become prominent and reduce the amplitude of pulsation of the outer cardiac border. To determine the incidence of pleuropericardial thickening about the heart in our general hospital population, 60 patients, 15 in each decade from ages forty-eight, with clinically normal hearts as far as could be determined by history, physical examination, electrocardiographic exami-

nation, and chest roentgenograms, were cinefluorographed. Seven of these patients showed prominent fat lines secondary to thickened pleuropericardium in one or more views on the cinefluorographic examination. These 7 patients, however, all had a normal amplitude of pulsation of the outer cardiac silhouette and of the fat lines. Three of these patients had obvious adhesions about the heart. In our series of 6 proven pericardial effusions, one had a normal amplitude of pulsation of the pleuropericardial border. Thus some difficulty in the differential diagnosis between pericardial effusion and pleuropericardial thickening can be expected.

SUMMARY

Over a four year period, 2,000 cinefluorographic examinations of the heart were performed at the Minneapolis Veterans Administration Hospital. Cinefluorography was found to be the best method for detecting and recording epicardial fat lines within the cardiac silhouette. Cinefluorography can record not only the apical epicardial fat line, but also other fat lines about the

heart which may be used in the diagnosis of pericardial effusion. If the apical epicardial fat line is detected and found to lie 2 mm. or more within the border of the left cardiac silhouette, the diagnosis of pericardial effusion is probable.

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AGENESIS OF A MAIN BRANCH OF THE PULMONARY ARTERY

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CONGENITAL anomalies of the pulmonary vessels have come to be recognized with greater frequency since angiocardiology has been more widely employed in the evaluation of congenital cardiovascular diseases. One such anomaly is complete absence of a main branch of the pulmonary artery. Nine cases in which a main branch of the pulmonary artery was absent have been encountered at the Mayo Clinic; these serve as the basis of this report. The diagnosis was suspected on the basis of the routine posteroanterior roentgenogram of the thorax and was established by angiocardiology in all except one case. This report considers only cases of complete absence of either the right or left pulmonary artery and does not include cases of absence or atresia of the main pulmonary trunk or absence of one pulmonary artery associated with complete agenesis of the ipsilateral lung.

REVIEW OF LITERATURE

A total of 52 cases of agenesis of a main branch of the pulmonary artery has been reported in the English literature. Between 1850 and 1952, only 9 cases were recorded in the literature, in all of which diagnosis was made at necropsy or at operation.²¹ Blalock² encountered 9 cases in 1948 when he reviewed the anatomic variations in 610 cyanotic patients given a clinical diagnosis of pulmonic stenosis, but he reported insufficient data for us to include 8 of these cases in the 52 reported cases. The first case in which this anomaly was diagnosed preoperatively in the living patient was reported by Madoff, Gaensler and Strieder²¹ in 1952. The diagnosis was established by angiocardiology. Subsequent to this re-

port of a single case, 42 additional cases have been reported in the literature.^{1,4,5,7,9-13,15,17,19,20,22,24,25,27-32}

In 48 of the 52 total cases recorded, the age and sex of the patient were given. Twenty-nine of these patients were females, and 19 were males. Twenty-seven were 10 years of age or younger at the time the anomaly was discovered. The oldest patient at the time of diagnosis was 48 years of age.²⁰

The symptoms and physical findings in the reported cases were in no way characteristic of this anomaly. If additional congenital cardiovascular malformations were present, the symptoms and signs usually reflected these rather than the absence of the pulmonary artery. When absence of a pulmonary artery occurred as an isolated anomaly, the patient frequently gave a history of one or more of the following: recurrent respiratory infections, hemoptysis, mildly reduced tolerance of exercise, dyspnea and shortness of breath with exertion.

In 26 of the 52 cases from the literature, the left main branch of the pulmonary artery was absent. In only 5 of these 26 cases (19 per cent) was the anomaly an isolated finding; in the remaining 21 cases, there were associated congenital cardiovascular defects. Tetralogy of Fallot was present in 14 (54 per cent) of these 26 cases of agenesis of the left pulmonary artery and is the most common congenital cardiovascular anomaly found in association with the absence of a main branch of the pulmonary artery. A right-sided aortic arch was present in 6 of the patients with associated tetralogy of Fallot. Of the remaining cases in which the associated con-

genital cardiovascular anomaly was recorded, one was associated with each of the following: right-sided aortic arch; atrial septal defect; interventricular septal defect and patent ductus arteriosus; and interventricular septal defect, over-riding aorta and aortopulmonary window. In 3 cases, the exact nature of the associated cardiovascular anomalies was not recorded.

If anomalous systemic arteries to the involved lung are excluded, 15 (58 per cent) of the 26 cases of absent right pulmonary artery occurred as isolated entities. In only one case was absence of the right pulmonary artery associated with tetralogy of Fallot. In this case, there was also complete situs inversus.²⁵ In 2 of the remaining 10 cases of agenesis of the right pulmonary artery with associated cardiovascular malformations, intracardiac defects (ventricular septal defect and Eisenmenger's complex, respectively) were found; and in 8, extracardiac defects were found which included coarctation of the aorta, other anomalies of the aortic arch, patent ductus arteriosus, aortopulmonary window and persistent truncus arteriosus.

In 21 of the 52 reported cases of agenesis of a main branch of a pulmonary artery, an anomalous systemic artery arose from the aortic arch or one of its branches and supplied the abnormal lung. In 11 of these 21 cases, the anomalous blood supply to the affected lung was via a single artery originating from the proximal portion of the aortic arch. This apparent aortic origin of the pulmonary artery was encountered in 9 cases of absence of the right pulmonary artery as compared to only 2 cases of absence of the left pulmonary artery. In 8 of the 21 cases, the anomalous vessel to the involved lung was described as arising from the innominate artery. In the remaining 31 cases, the presence of an anomalous artery was not described.

The blood supply to the involved lung in cases of agenesis of a main branch of the pulmonary artery, except for that occurring through anomalous arteries as just described, is entirely by means of collateral circulation. The major portion of this

collateral circulation is by way of the bronchial arteries. Experimental studies on rats⁸ and dogs¹⁸ have demonstrated an enormous increase in size of the bronchial arteries after ligation of the pulmonary artery. Four to 6 months after ligation of the pulmonary artery, the affected lung will also show pre-capillary anastomoses between the enlarged bronchial arteries and the peripheral pulmonary arteries. Cockett and Vass,⁶ working with dogs, demonstrated that the enlarged bronchial arteries received tributaries from the esophageal plexus, intercostal, internal mammary and pericardiacophrenic vessels after ligation of the pulmonary artery. An additional route of collateral systemic circulation to the lung was through new blood channels which may form in pleural adhesions and anastomose directly with branches of the pulmonary artery. Bloomer and associates³ also demonstrated a marked increase in the blood flow in the bronchial arteries of dogs after ligation of a pulmonary artery. This increased flow has been shown to be largely a burden of the left heart whose output becomes approximately a third greater than that of the right heart.

Pulmonary function and bronchspirometric studies were recorded in several of the cases reported.^{5, 13, 21, 27-29} Reduction in volume of the affected lung is nearly always present, and this is documented by a decrease in the ventilation of this lung as compared to the normally vascularized lung. The total pulmonary ventilation, however, is increased at rest, since both lungs are ventilated but only the normal lung is taking up a significant quantity of oxygen. Breathing 100 per cent oxygen or exercising produces an oxygen-pressure gradient between the alveolar air and the systemic blood which perfuses the affected lung, and oxygen will be absorbed by the abnormal lung under these conditions. Oxygen saturation of systemic arterial blood is normal or near normal at rest but falls with exercise.

EMBRYOLOGIC ASPECTS

A brief review of the development of the

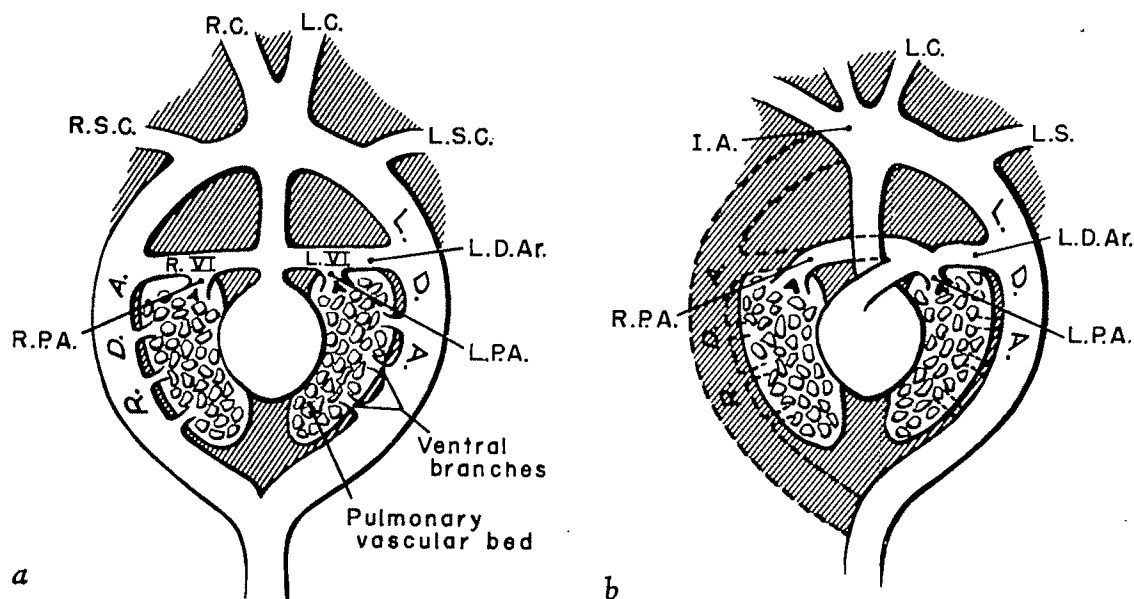


FIG. 1. *Normal development.* R. VI and L. VI = right and left sixth arches; R.D.A. and L.D.A. = right and left dorsal aorta; R.P.A. and L.P.A. = right and left pulmonary artery; R.S.C. and L.S.C. = right and left subclavian artery; R.C. and L.C. = right and left carotid; L.D.Ar. = left ductus arteriosus, and I.A. = innominate artery.

(a) Early stage. The paired sixth arches are present and each has been divided into its proximal and distal portion. The proximal portions of the two sixth arches are destined to become the right and left main branches of the pulmonary artery. The distal portion of the left sixth arch is destined to form the ductus arteriosus and the distal portion of the right sixth arch normally disappears. The ventral branches of the right and left dorsal aorta supply the pulmonary vascular bed at this stage.

(b) At birth. The distal portion of the right sixth arch and the right dorsal aorta have disappeared. The ventral branches of both the right and left dorsal aorta have been interrupted and the common truncus arteriosus of early stages of development is no longer present. Blood supply to each lung is now by way of the pulmonary arteries derived from the proximal portions of the paired sixth arches. The distal portion of the left sixth arch persists as the left ductus arteriosus.

pulmonary arteries is helpful in the understanding of their anomalies.^{29,31} Figure 1 shows schematic representations of their development.

The pulmonary artery branches are derived from the primitive sixth aortic arches. With normal maturation, the proximal portions of the sixth arches persist to form the right and left main branches of the pulmonary artery. On the right side, the distal portion of the sixth arch disappears, while on the left side, the distal portion persists as the ductus arteriosus. The pulmonary vascular bed is established separately and is not dependent on the sixth arch for its development. This pulmonary plexus of vessels is connected in its early stages to ventral branches of the dorsal aorta. These systemic connections

normally disappear at a later stage in development, and the pulmonary vascular bed then becomes supplied by developing branches of the right and left pulmonary arteries.

Disappearance of the proximal portion of either the right or the left sixth arch results in absence of a main branch of the pulmonary artery (Fig. 2a). The peripheral pulmonary vessels, including the pulmonary veins, may be normally formed when a main branch of the pulmonary artery is absent because they develop independently.

Persistence of the distal part of the right sixth arch and a portion of the right dorsal aorta, combined with disappearance of the proximal right sixth arch, results in an apparent right pulmonary artery arising from the ascending aorta (Fig. 2b). The concept

that this vessel is a persistent right ductus arteriosus is strongly supported by the histologic demonstration of typical ductal tissue near its site of origin from the aorta.³¹

It would be expected that absence of the left pulmonary artery, resulting from disappearance of the proximal portion of the left sixth arch, would be frequently associated with persistence of the distal portion of the left sixth arch as a patent ductus arteriosus. However, the combination of agenesis of the left pulmonary artery and a

patent left ductus arteriosus is rarely encountered.

No explanation is apparent as to why absence of the left pulmonary artery is so frequently associated with tetralogy of Fallot or why absence of the right pulmonary artery occurs most often as an isolated anomaly or in association with extracardiac defects.

PRESENT STUDY

The significant findings in 9 cases of

TABLE I

SUMMARY OF FINDINGS IN NINE PATIENTS WITH AGENESIS OF A MAIN BRANCH OF THE PULMONARY ARTERY*

Case, figure, age, yr., and sex	Clinical aspects	Branch absence and associated malformations	Roentgenographic findings	Angiocardiography	Comment
Case 1 (Fig. 3) 5M	Retarded physical development; limitation of activities, exertional dyspnea and spells of cyanosis	L. branch; tetralogy of Fallot	Cardiac enlargement; decreased volume of L. lung with shift of mediastinum to L.; absence of normal L. hilar shadow and bronchial arteries identified in L. lung	VSD with simultaneous filling of aorta, main pulmonary artery and its R. main branch; infundibular pulmonary stenosis; LPA absent	In Dec., 1955, VSD was closed and pulmonary valvulotomy done; absence of LPA was verified. Marked improvement after operation
Case 2 (Fig. 4) 4F	Normal development; recurrent respiratory infections	L. branch; VSD and valvular pulmonic stenosis	Decreased volume of L. lung with mediastinal shift to L.; L. hilar shadow obscured by shifted heart; RPA dilated. Fluoroscopy: no mediastinal shift with respiration	VSD; pulmonary valvular stenosis; RPA dilated; LPA absent	In Aug., 1957, VSD was closed and pulmonary valvulotomy done. Much improvement after operation
Case 3 (Fig. 5) 5M	Cyanosis since infancy. R. middle lobectomy at age 6 mo. for congenital lobar emphysema; L. thoracotomy at age 2 yr.; entire LLL sequestration	L. branch; VSD; pulmonic valvular stenosis; sequestration of LLL	Cardiac enlargement; decrease in vascularity of L. lung; RPA dilated	VSD; pulmonary valvular stenosis; RPA dilated; LPA absent	In Aug., 1961, operation for VSD and pulmonary stenosis. Too early to evaluate results
Case 4 (Fig. 6) 4M	Frequent respiratory infection; recurrent cough	L. branch; tetralogy of Fallot	Decreased volume of L. lung with shift of mediastinum to L.; decreased vascularity in L. lung and bronchial arteries identified on L.	Not done	In Aug., 1965, operation for VSD and infundibular pulmonary stenosis; absence of LPA confirmed
Case 5 (Fig. 7) 6M	Family history of asthma; intermittent wheezing and coughing; frequent bouts of asthmatic bronchitis and pneumonitis	R. branch; no associated malformations	Decreased volume of R. lung with mediastinal shift to R.; normal R. hilar shadow absent; L. hilar shadow prominent. Bronchogram normal	Venous angiogram normal except for absence of RPA	Patient's respiratory symptoms aggravated by allergic diathesis
Case 6 (Fig. 8) 7M	Easy fatigability and frequent respiratory infections	L. branch; no associated anomalies	Decreased volume of L. lung with mediastinal shift to L.; normal L. hilar shadow absent	Selective cineangiography normal except for absence of LPA	Absence of LPA, as occurred in this case, is rarely an isolated anomaly
Case 7 (Fig. 9) 58M	Pneumonia as a child. Hypertension for 30 yr.; angina pectoris; cyst removed from R. kidney at age 55 yr. Mild cyanosis of nails. BUN 66-90	L. branch; aortic arch on R.	Decreased volume of L. lung and mediastinal shift to L.; R. aortic arch with rib notching on L.; pleural thickening over L. lung	Enlargement of LV; aortic arch on R.; RPA dilated; LPA absent	Oldest patient to be reported with this condition
Case 8 (Fig. 10) 6F	Spells of cyanosis, easy fatigability and heart murmur known since infancy	L. branch; persistent truncus arteriosus	Aortic arch on R.; decreased volume of L. lung with mediastinal shift to L.; RPA prominent; slight increase in peripheral vascularity on R.	Type 1 truncus arteriosus; aortic arch on R.; LPA absent	Absence of main branch of PA is rarely found with truncus arteriosus. Second such case to be reported
Case 9 (Fig. 11) 8M	Cyanosis, easy fatigability, and marked limitation of activity since infancy; cyanotic at rest; clubbing of fingers and toes; congenital strabismus and 8th nerve deafness on L.	L. branch; total anomalous pulmonary venous connection; patent ductus arteriosus	Decreased volume of L. lung with mediastinal shift to L.; contour of heart and superior mediastinum suggests total anomalous venous connection	Total anomalous pulmonary venous return to L. superior vena cava; patent ductus arteriosus with reversal of flow and agenesis of LPA	First case reported of agenesis of a main branch of PA associated with total anomalous pulmonary venous connection

* Abbreviations: L. and R. =left and right; LPA, RPA, and PA=left and right pulmonary artery and pulmonary artery; VSD=ventricular septal defect; LLL=left lower lobe of lung; LV=left ventricle; BUN=blood urea nitrogen.

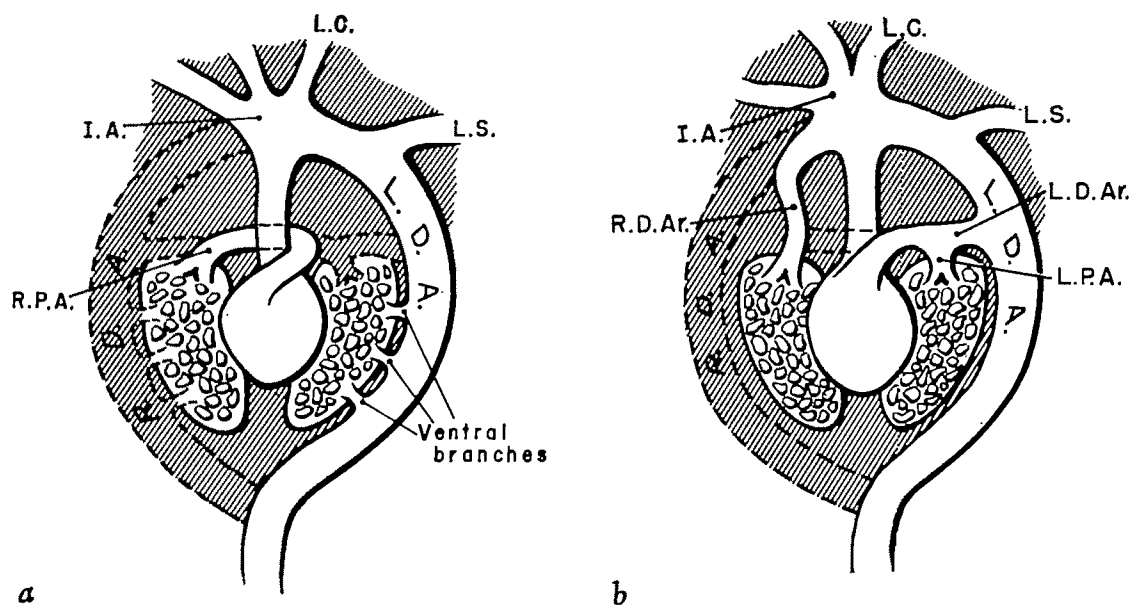


FIG. 2. *Abnormal development.* Same abbreviations as in Figure 1. R.D.Ar. = right ductus arteriosus.

(a) Developmental basis of agenesis of a main branch of the pulmonary artery. This anomaly results when regression of the proximal portion of the sixth arch occurs on either side. A ventral branch (or branches) of the dorsal aorta may persist to form an anomalous systemic artery to the involved lung.

(b) The anomaly resulting when disappearance of the proximal portion of the right sixth arch occurs with persistence of the distal portion of the sixth arch and of a part of the right dorsal aorta. This results in an apparent right pulmonary artery arising from the ascending aorta.

agenesis of a main branch of the pulmonary artery encountered at the Mayo Clinic are presented in Table 1 (Cases 1 to 9; Fig. 3 to 11). In each case, the diagnosis was suspected on the basis of the routine posteroanterior roentgenogram of the thorax. In 8 patients, the diagnosis was established by angiocardiology, and in 3 of these was later confirmed at operation. In the one patient on whom an angiocardiology was not done, the diagnosis was established at the time of operation for tetralogy of Fallot.

Seven of these 9 patients (78 per cent) were males in contrast to the 60 per cent incidence in females in the cases previously reported in the literature. Eight of our 9 patients were 8 years of age or younger at the time of diagnosis, while the remaining patient was 58 years of age. This latter patient is the oldest reported with this condition.

A review of the 52 cases reported in the literature reveals an equal incidence of

agenesis of the right and left branches of the pulmonary artery. In contrast, the right main branch of the pulmonary artery was absent in only one of our cases. The agenesis of the right pulmonary artery was an isolated anomaly without additional congenital cardiovascular defects in this case. Seven of the 8 patients with agenesis of the left branch of the pulmonary artery had associated congenital cardiovascular malformations. In the cases recorded in the literature and in the present series, absence of the left pulmonary artery occurred much more frequently in association with other cardiac malformations than did absence of the right pulmonary artery. The associated malformations in the patients comprising this study, all of which occurred in patients with agenesis of the left pulmonary artery, included: tetralogy of Fallot; ventricular septal defect with valvular pulmonic stenosis; right-sided aortic arch; persistent truncus arteriosus; and total anomalous pulmonary venous connection

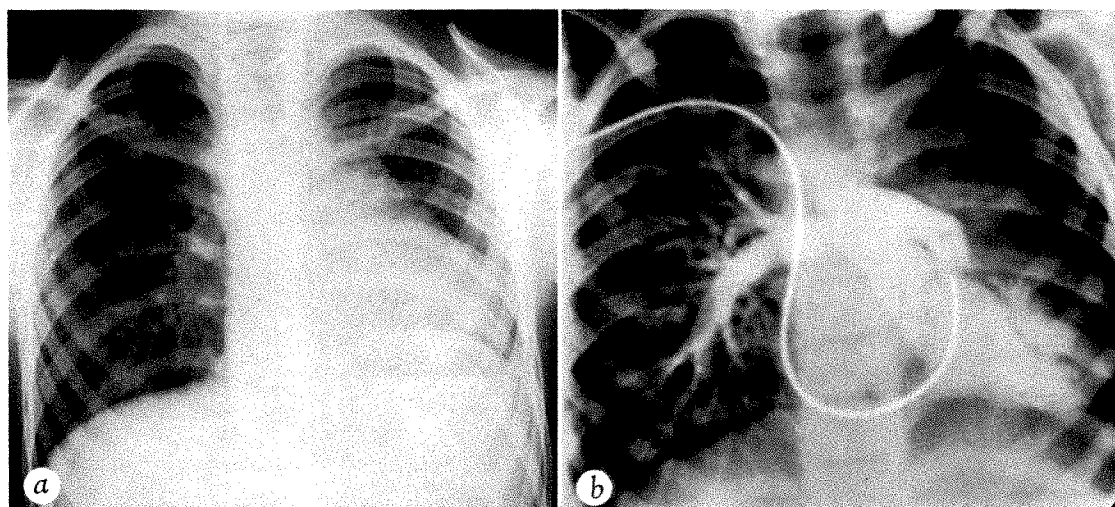


FIG. 3 (Case 1). (a) Posteroanterior roentgenogram of the thorax showing decreased volume of left lung with shift of mediastinal structures to the left. Left hemidiaphragm is elevated. Vascular shadows in left hilus are less prominent than those on the right and suggest presence of enlarged bronchial arteries. Cardiac enlargement.

(b) Angiocardiogram with injection of medium into right ventricle showing tetralogy of Fallot and agenesis of left main branch of pulmonary artery.

with patent ductus arteriosus. Sequestration of the left lower lobe was present in

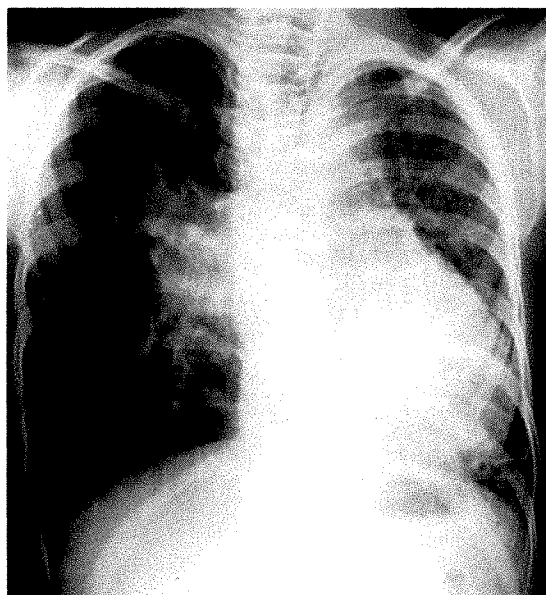


FIG. 4 (Case 2). The thorax of a patient with agenesis of left pulmonary artery associated with ventricular septal defect and valvular pulmonary stenosis. Volume of left lung is diminished and left hemithorax is small with shift of mediastinal structures to left. Bronchial arteries are prominent in the left lung. Right pulmonary artery is dilated.

one case with complete absence of the left main branch of the pulmonary artery and associated ventricular septal defect and valvular pulmonary stenosis.

Four of the 9 patients gave a history of repeated respiratory infections and pneumonia, but none had experienced hemoptysis. The symptoms in most instances were thought to reflect the associated cardiovascular disease rather than the absence of a main branch of the pulmonary artery.

Cardiac surgery was performed on 4 patients. In each of these 4 patients, the intracardiac defect consisted of a ventricular septal defect and either valvular or infundibular pulmonic stenosis (tetralogy of Fallot). Two of these patients were operated on in August, 1961, and at the time of this writing it was too early to evaluate the results. The 2 remaining patients were operated on in December, 1955, and August, 1957, respectively, and marked clinical improvement resulted in both cases.

Several of the patients had unusual signs. In Case 7 (Fig. 9) unilateral notching of the ribs was noted on the same side as the absence of the pulmonary artery.²⁶ This finding has been reported in only one other

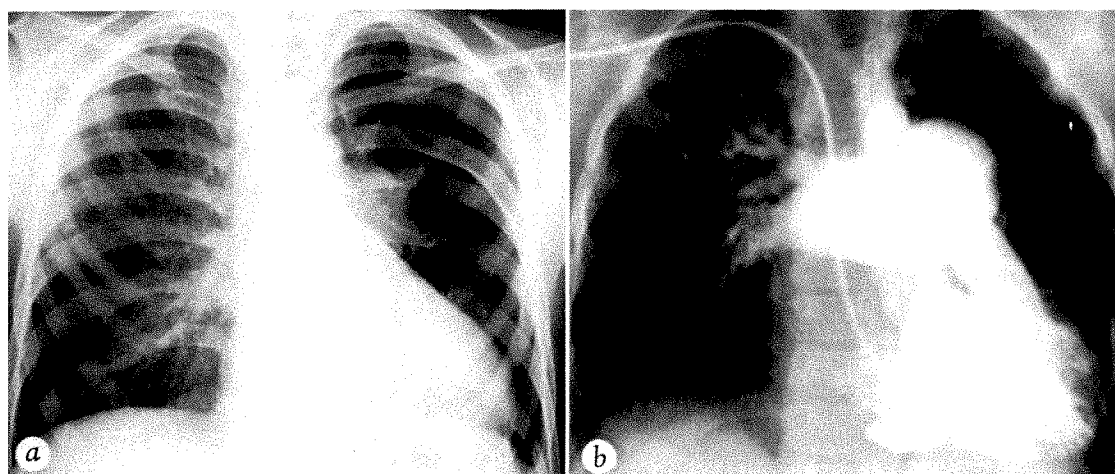


FIG. 5 (Case 3). (a) Roentgenogram of thorax showing absence of pulmonary vascular markings in left lung. Left lung appears hyperlucent. Few bronchial arteries are visible in the left lung. Right pulmonary artery is enlarged.

(b) Angiocardiogram with injection into right ventricle showing absence of left main branch of pulmonary artery. There is a ventricular septal defect and valvular pulmonary stenosis.

case.¹⁰ Working with dogs, Cockett and Vass⁶ showed that the intercostal arteries supply tributaries to the enlarged bronchial arteries and also to the new blood channels which form in pleural adhesions after operation and ligation of the ipsilateral pulmonary artery. In view of these experimental findings, the notched ribs may be explained on the basis of increased blood flow through the intercostal arteries.

Cases 2 and 3 (Fig. 4 and 5) are examples of agenesis of the left pulmonary artery associated with a ventricular septal defect and valvular pulmonary stenosis. A markedly dilated right pulmonary artery was seen on the plain roentgenograms and angiocardiograms in each of these cases. Slight enlargement of the contralateral pulmonary artery is a frequent finding in absence of a main branch of the pulmonary artery, but the enlargement in these two cases was greater than is usually encountered. This finding probably represents poststenotic dilatation of the right pulmonary artery in the presence of valvular pulmonary stenosis and absence of the left pulmonary artery.

To the best of our knowledge, agenesis of a main branch of the pulmonary artery

has not previously been reported in the English literature in association with total anomalous pulmonary venous connection (Case 9; Fig. 11).

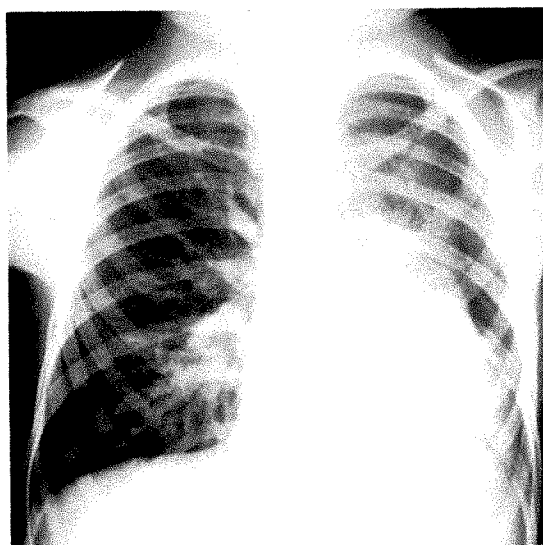


FIG. 6 (Case 4). Agenesis of left pulmonary artery and tetralogy of Fallot. Roentgenogram shows decreased volume of left hemithorax, shift of mediastinal structures to left and elevation of left hemidiaphragm. Lacy network of vessels radiating from left hilar region is suggestive of enlarged bronchial arteries. Pulmonary vasculature in right lung is increased.

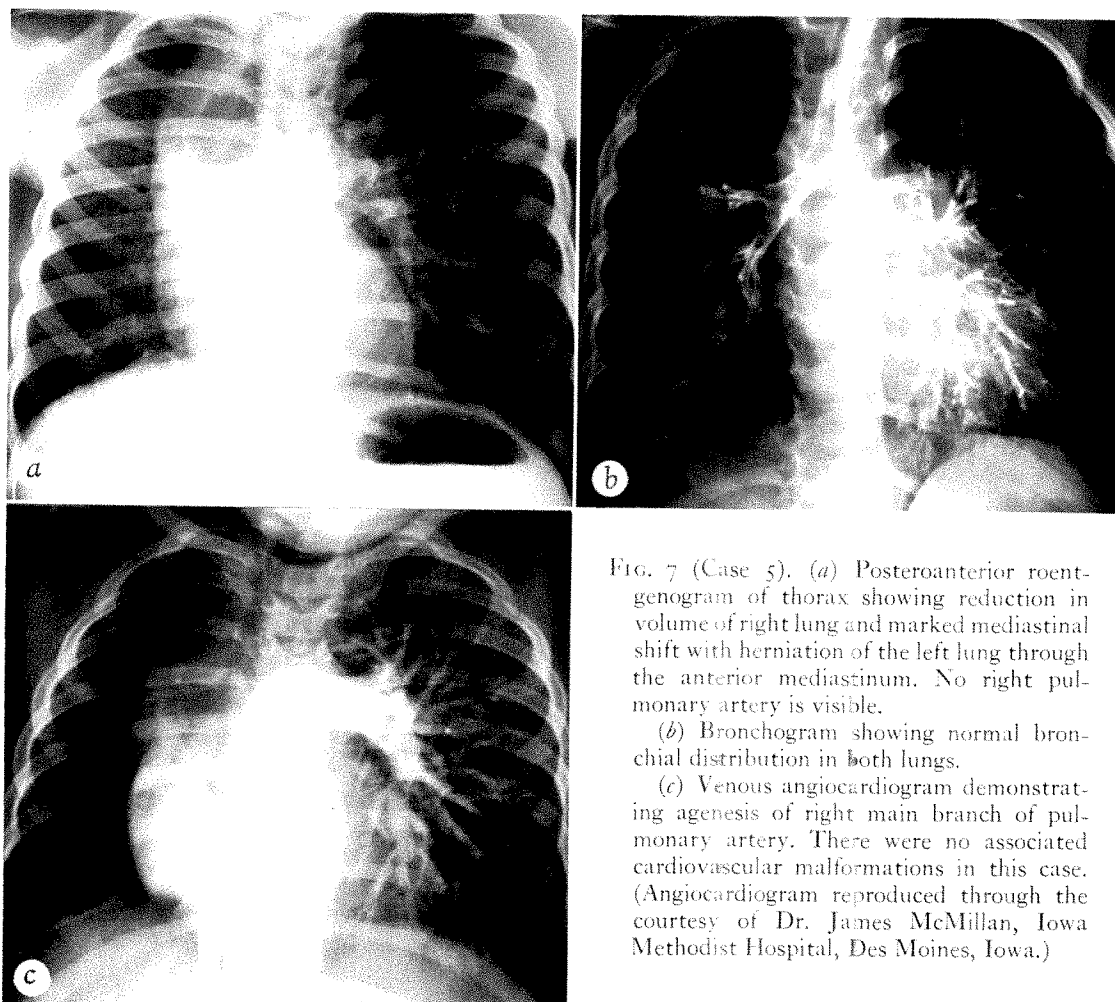


FIG. 7 (Case 5). (a) Posteroanterior roentgenogram of thorax showing reduction in volume of right lung and marked mediastinal shift with herniation of the left lung through the anterior mediastinum. No right pulmonary artery is visible.

(b) Bronchogram showing normal bronchial distribution in both lungs.

(c) Venous angiogram demonstrating agenesis of right main branch of pulmonary artery. There were no associated cardiovascular malformations in this case. (Angiogram reproduced through the courtesy of Dr. James McMillan, Iowa Methodist Hospital, Des Moines, Iowa.)

COMMENT ON ROENTGENOLOGIC FINDINGS

The conventional posteroanterior roentgenogram of the thorax shows changes which are almost always sufficiently characteristic to alert the examiner to the presence of agenesis of a main branch of the pulmonary artery.^{14,16} The involved lung, with rare exceptions, is reduced in volume but is normally aerated (Fig. 3 through 11). The thoracic roentgenogram demonstrates slight to moderate shift of the mediastinal structures and elevation of the hemidiaphragm on the affected side. The thorax may be asymmetric, and the intercostal spaces narrowed on this side. Compensatory emphysema of the opposite lung with increased radiolucency and herniation of this lung through the anterior mediastinum is frequently present.

num is frequently present.

The normal hilar vascular shadow is absent on the affected side. This is more readily demonstrated when the right pulmonary artery is absent, the left hilus often being obscured by the heart shadow which is shifted to the left in cases of an absent left pulmonary artery. The presence of a lacy network of small vessels extending out peripherally from the abnormal hilar shadow indicates enlarged bronchial arteries. Rib notching may rarely be seen on the involved side (Fig. 9). The contralateral hilar vascular shadow is often enlarged and prominent due to the increased blood flow through the remaining pulmonary artery.

At fluoroscopy, with deep inspiration, the mediastinum remains stationary or, at

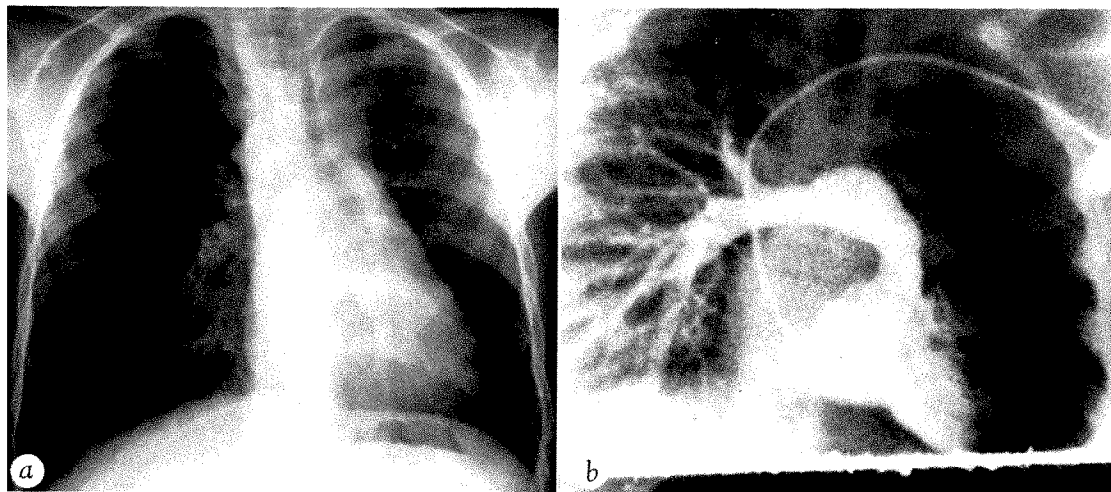


FIG. 8 (Case 6). (a) Roentgenogram of thorax demonstrating reduced volume of the left lung with mediastinal shift to the left. The normal left hilar shadow is not identified and the vascular pattern in the left lung suggests enlarged bronchial arteries.

(b) Cineangiogram with injection of medium into the right ventricle reveals agenesis of the left main branch of the pulmonary artery. No associated cardiovascular defects were found in this case. (Angiogram reproduced through the courtesy of Dr. Robert H. French, Emory University Hospital, Atlanta, Georgia.)

most, shifts slightly toward the affected lung. This lack of significant mediastinal shift with inspiration is explained by the

unimpeded ventilation of the involved lung and is helpful in excluding other conditions such as atelectasis of a lobe or an entire lung.

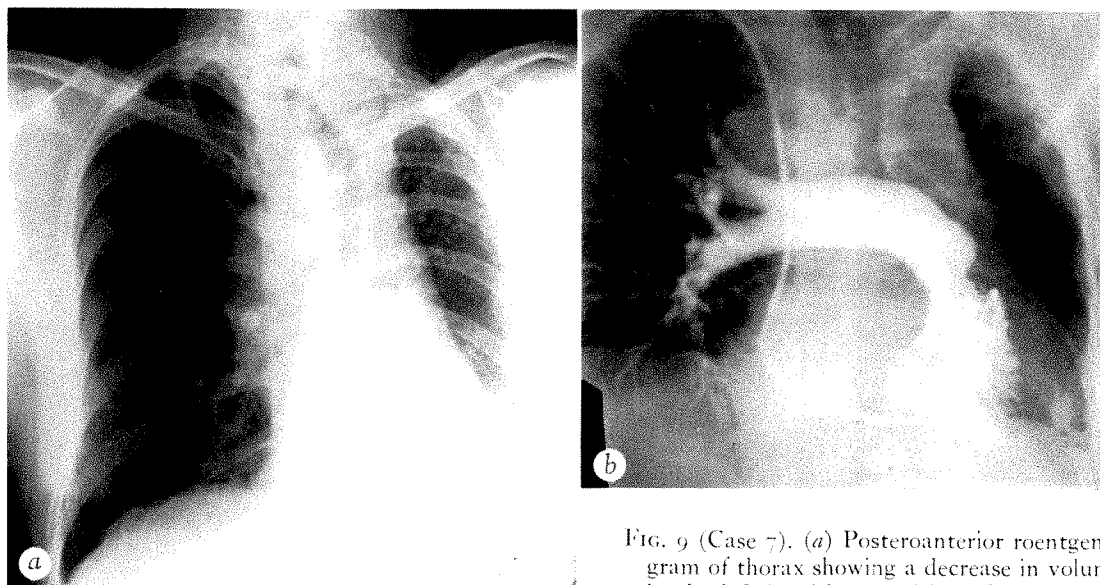


FIG. 9 (Case 7). (a) Posteroanterior roentgenogram of thorax showing a decrease in volume in the left hemithorax with shift of the me-

diastinum to the left and slight elevation of the left hemidiaphragm. Pleural thickening is present about the left lung and notching of the ribs is present on the left side. The left pulmonary artery is not seen. The aortic arch is on the right side.

(b) Angiogram with injection into the right ventricle demonstrates complete agenesis of the left main branch of the pulmonary artery. Later film confirmed the right-sided aortic arch. There were no other malformations in this case.

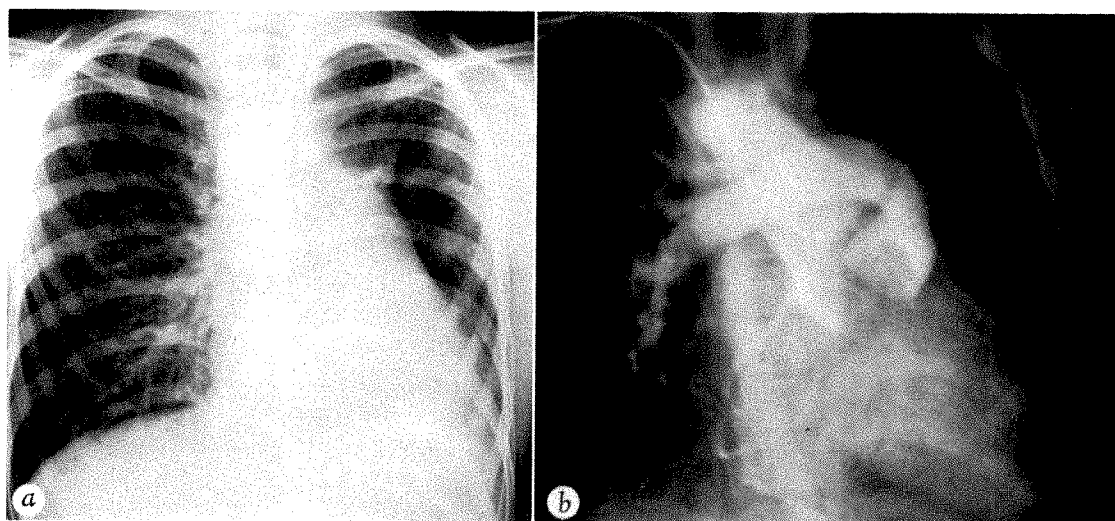


FIG. 10 (Case 8). (a) Roentgenogram of thorax showing reduction of the volume of the left lung with shift of the mediastinal structures to the left. The pulmonary vasculature on the right is increased while the vasculature on the left is diminished and suggestive of enlarged bronchial arteries. The aortic arch is on the right side and there is cardiac enlargement.

(b) Thoracic aortogram showing Type 1 truncus arteriosus with agenesis of the left pulmonary artery.

Bronchography will show a normally developed bronchial tree, but the individual bronchi may be crowded together. Bron-

chiectasis has been reported in some of these patients who have had repeated respiratory infections. This procedure will

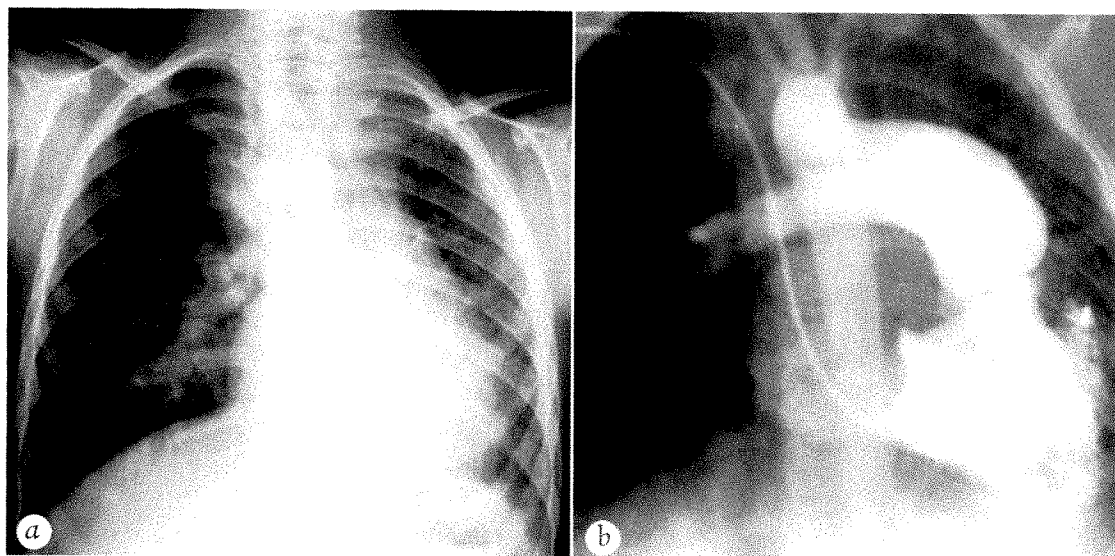


FIG. 11 (Case 9). (a) Roentgenogram of thorax shows reduction in volume of the left hemithorax with slight shift of the mediastinum to the left. The right pulmonary artery is prominent and the left pulmonary artery is not identified. The contour of the superior mediastinum suggests total anomalous pulmonary venous connection.

(b) Angiocardiogram with injection into the right ventricle. There is absence of the left main branch of the pulmonary artery. Aortic arch and descending aorta opacified by way of a patent ductus arteriosus. There was evidence in later films of total anomalous pulmonary venous connection to a left superior vena cava.

exclude partial or complete agenesis of the lung, which may be associated with a hypoplastic or absent pulmonary artery.

The establishment of a definite diagnosis of absence of a main branch of the pulmonary artery depends on angiocardiology. The main pulmonary artery and its single main branch will be opacified with contrast material. No pulmonary artery branch to the affected lung will be opacified and no contrast material will enter this lung during the phase of pulmonary artery filling. The normal site of departure of the missing pulmonary artery from the main pulmonary trunk will be convex and smooth in contour, and no evidence of a portion of the proximal pulmonary artery will be found in this region. Roentgenograms made during aortic filling will show contrast material entering the abnormal lung via the bronchial arteries and in some cases from an anomalous systemic artery arising from the aorta or one of its branches.

While venous angiocardiology is usually adequate to demonstrate anomalies of the pulmonary arteries, selective angiocardiology with injection into the right ventricle or main pulmonary artery may be carried out at the time of cardiac catheterization and is the method of choice. With this method, the concentration of contrast material within the pulmonary arteries can be readily controlled, and maximal visualization of the pulmonary vessels will be achieved. In addition, the rapid injection of a bolus of contrast medium into the right ventricle, or preferably into the main pulmonary artery, will give better opacification of the left heart and thoracic aorta, thereby increasing the chance of visualization of any anomalous arteries supplying the involved lung. Such an anomalous artery, of course, will be best demonstrated by means of retrograde thoracic aortography.

SUMMARY AND CONCLUSIONS

Absence of a main branch of the pulmonary artery is a rare malformation, which is usually first suspected from the roent-

genogram of the thorax. This malformation is frequently associated with other congenital anomalies of the heart and great vessels but may occur as an isolated malformation.

The symptoms of patients with agenesis of a main branch of the pulmonary artery frequently include one or more of the following: recurrent respiratory infections, shortness of breath with exercise, hemoptysis, and slight reduction in tolerance to exercise.

The embryologic basis of agenesis of a main branch of the pulmonary artery may be logically explained on the basis of interruption of the proximal portion of the primitive right or left sixth aortic arch from which these arteries are normally derived.

The roentgenologic findings in this condition are, in most instances, characteristic. These consist of loss of volume of the involved lung, absence of the normal hilar shadow on the affected side, and the demonstration of enlarged bronchial arteries on this side. Exact diagnosis in each instance must depend, however, on angiocardiology.

Fifty-two cases of agenesis of a main branch of the pulmonary artery have been reported in the literature. The findings in these reported cases have been briefly reviewed and 9 additional cases have been reported in detail.

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THE NORMAL ROENTGENOGRAPHIC MEASUREMENT OF THE RIGHT DESCENDING PULMONARY ARTERY IN 1,085 CASES*

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IN RECENT years quantitation of pulmonary hypertension in acquired and congenital heart disease has been attempted by measuring the right descending pulmonary artery on chest roentgenograms.^{1,2,3,5} The presence of dilatation of the right descending pulmonary artery is a reliable roentgenologic sign of pulmonary hypertension, though no linear correlation exists between pulmonary artery widths and pulmonary artery pressure.⁵

The data in normal measurements of the right descending pulmonary artery are either insufficient or lacking in a large number of reported cases.

The purpose of this paper is to report the normal roentgenographic measurement of the right descending pulmonary artery in 1,085 cases.

MATERIAL AND METHODS

One thousand and eighty-five normal adults were studied from August, 1959 through May, 1961. These cases were carefully selected from known normal patients. For the purposes of this study, these cases were divided into four groups by age and sex. Group I consists of 290 normal adult males ranging in age from 18 years to 40 years. Group II consists of 482 normal adult females ranging in age from 18 years to 40 years. Group III consists of 142 normal adult males of 41 to 70 years of age. Group IV consists of 171 normal adult females of 41 to 72 years of age. The heights and weights of these cases were also recorded. There were no racial characteristics in the measurements.

All posteroanterior chest roentgenograms were obtained in deep inspiration and forceful expiration at a film-target distance

of 72 inches. The right descending pulmonary artery was measured on both inspiratory and expiratory films at its widest point near the bifurcation of the artery from the lateral segment of the right middle lobe and above the branching of the middle basilar artery. This measurement point usually lies between the right 8th and 9th ribs posteriorly in deep inspiration (Fig. 1A and 2A) and less commonly between the right 7th and 8th ribs posteriorly. Occasionally, it also lies over or above the right 7th rib posteriorly, especially in short female adults. It is apt to be slightly elevated upward on the expiratory films and usually lies just below or over the right 8th rib posteriorly (Fig. 1B and 2B). The medial boundary of the right descending pulmonary artery is ordinarily well shown by the air-filled right main stem bronchus. The immediate hilar region was avoided for the measurement because of overlying shadows of the superior and inferior pulmonary veins. Very slight right or left anterior obliquity, less than 10 degrees, would help to differentiate the right descending pulmonary artery from overlying shadows of pulmonary veins.

RESULTS

Group I. (Normal males, 18 to 40 years).

The range of the right descending pulmonary artery measurements was 9–16 mm. in inspiration and 8–15 mm. in expiration (Fig. 4). The mean inspiratory measurement was 13.9 mm. as compared to 11.8 mm. for the expiratory measurement. The range of difference between inspiratory and expiratory measurements of the right descending pulmonary artery was 1–3 mm.

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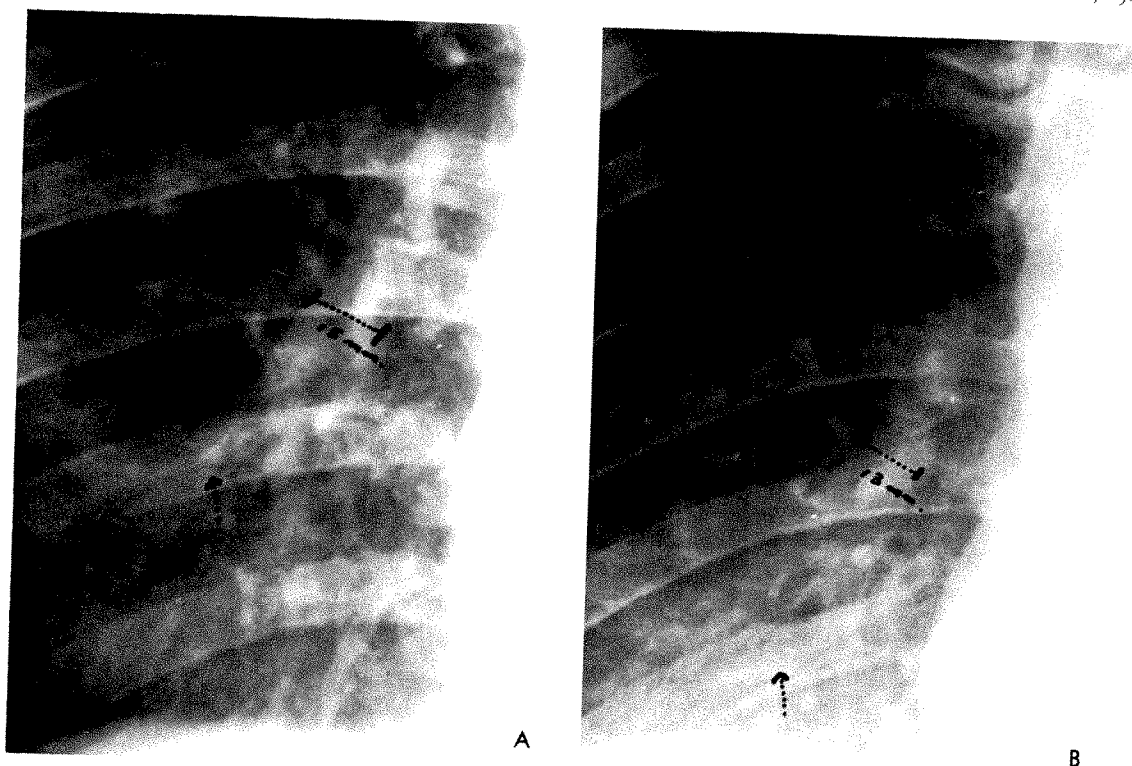


FIG. 1. (A) Inspiratory measurement of the right descending pulmonary artery in a normal 37 year old male. The measurement is 15 mm. The right descending pulmonary artery is measured at its widest point near the bifurcation of the artery from the lateral segment of the right middle lobe and above the branching of the middle basilar artery. The measurement point lies between the right 8th and 9th rib. The solid arrow indicates the lateral segment of the right middle lobe artery. (B) Expiratory measurement of the right descending pulmonary artery in the same case. The measurement point now lies between the right 7th and 8th rib. The measurement is 13 mm. The solid arrow indicates the lateral segment of the right middle lobe artery. The broken arrow indicates the right 9th rib.

(1 mm. in 42 cases; 2 mm. in 211 cases; and 3 mm. in 37 cases). The mean difference was 2.0 mm.

Group II. (Normal females, 18 to 40 years).

The range of measurement of the right pulmonary artery in this group was 9–15 mm. (Fig. 5) with a mean measurement of 12.4 mm. in inspiration. The expiratory measurements showed a range of 7–14 mm., with a mean measurement of 10.5 mm. The range of difference between inspiratory and expiratory measurements of the right descending pulmonary artery was 1–3 mm. (1 mm. in 103 cases; 2 mm. in 319 cases; and 3 mm. in 60 cases). The mean difference was 1.9 mm.

Group III. (Normal older males, 41 to 70 years).

The range of measurement of the right

descending pulmonary artery in this group in inspiration was 10–16 mm. (Fig. 6), with a mean of 14.3 mm. The expiratory measurements showed a range of 9–15 mm., with a mean of 12.5 mm. The range of difference between inspiratory and expiratory measurements of the right descending pulmonary artery was 1–3 mm. (1 mm. in 37 cases; 2 mm. in 101 cases; and 3 mm. in 4 cases). The mean difference was 1.7 mm.

Group IV. (Normal older females, 41 to 72 years).

The range of measurement of the right descending pulmonary artery in inspiration was 9–15 mm. (Fig. 7), with a mean of 13.1 mm. The range of expiratory measurement was 7–14 mm., with a mean of 11.2 mm. The range of difference between inspiratory and expiratory measurements of the right descending pulmonary artery

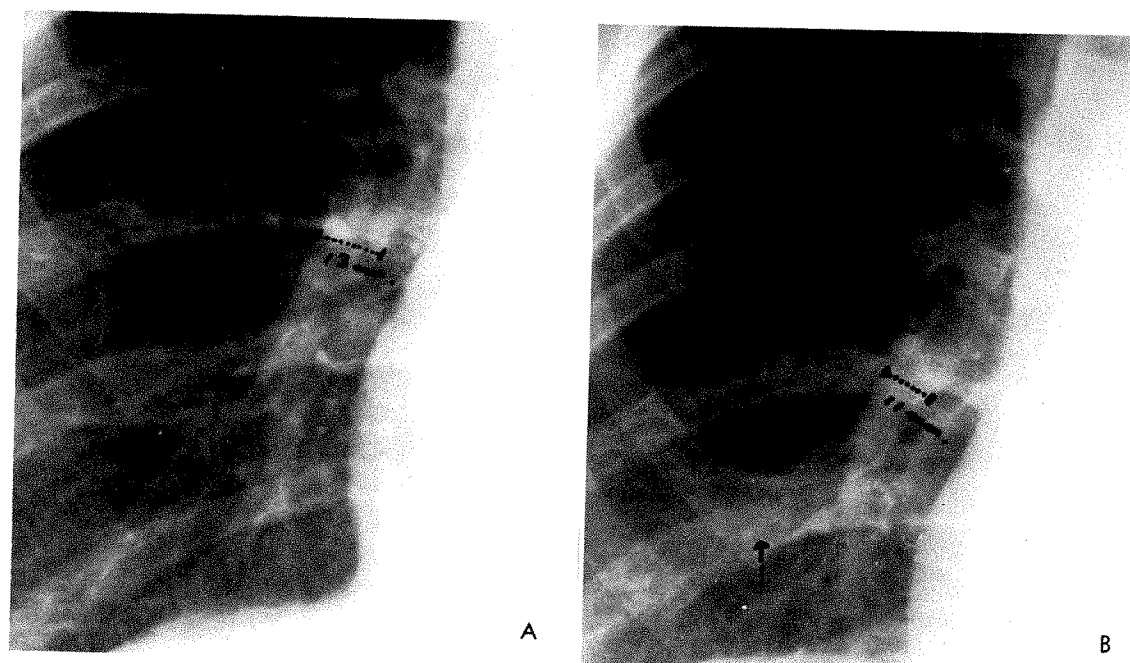


FIG. 2. (A) Inspiratory measurement of the right descending pulmonary artery in a normal 30 year old female. The measurement is 13 mm. The measurement point lies between the right 8th and 9th rib. The solid arrow indicates the lateral basilar segment of the right middle lobe artery. The broken arrow indicates the right 9th rib. (B) Expiratory measurement of the right descending pulmonary artery in the same case. The measurement is 11 mm. The solid arrow indicates the lateral segment of the right middle lobe artery. The broken arrow indicates the right 9th rib.

was 1–3 mm. (1 mm. in 34 cases; 2 mm. in 117 cases; and 3 mm. in 20 cases). The mean difference was 1.9 mm.

The following additional observations were also made:

1. The largest inspiratory measurement of the right descending pulmonary artery in all normal males, 432 cases (Group I and III) was 16 mm. and the smallest inspiratory measurement was 9 mm. The largest inspiratory measurement in all normal females, 653 cases (Group II and IV) was 15 mm. and the smallest measurement was 7 mm.

2. The largest expiratory measurement of the right descending pulmonary artery in all normal males, 432 cases (Group I and III) was 15 mm. as compared to 14 mm. for the normal females, 653 cases (Group II and IV).

3. Though there was a wide range of normal variation in the inspiratory and expiratory measurements, a slightly greater mean measurement was noted in males than in females.

4. The range of difference between inspiratory and expiratory measurements was 1–3 mm. in all groups. In 748 cases (69 per cent) this was 2 mm.

5. There was no strict linear correlation between the height and weight, and the measurements of the right descending pulmonary artery. However, a slightly greater mean measurement was noted in taller and heavier subjects.

6. Although the age was not the greatest factor, a slightly greater mean measurement was found in older groups (Group III and Group IV).

DISCUSSION

The phenomenon of changing size of the pulmonary vessels during inspiration was well studied by Westermarck⁶ who emphasized the importance of the intra-alveolar pressure. During inspiration, when the intra-alveolar pressure falls to from –5 to –40 cm. of water, the filling of the vessels in the lungs considerably increases and thus it enlarges the size of the vessels. Dur-

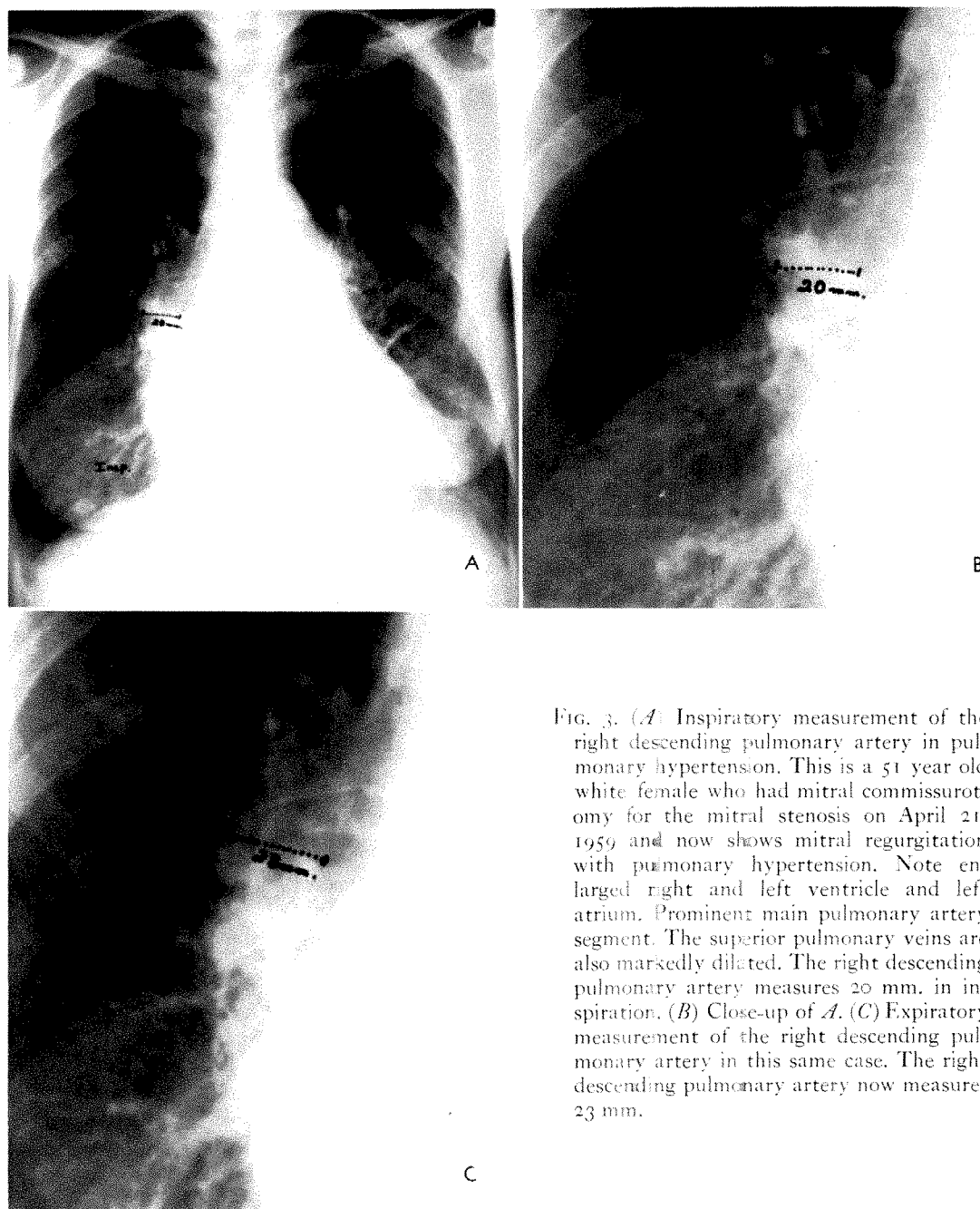


FIG. 3. (A) Inspiratory measurement of the right descending pulmonary artery in pulmonary hypertension. This is a 51 year old white female who had mitral commissurotomy for the mitral stenosis on April 21, 1959 and now shows mitral regurgitation with pulmonary hypertension. Note enlarged right and left ventricle and left atrium. Prominent main pulmonary artery segment. The superior pulmonary veins are also markedly dilated. The right descending pulmonary artery measures 20 mm. in inspiration. (B) Close-up of A. (C) Expiratory measurement of the right descending pulmonary artery in this same case. The right descending pulmonary artery now measures 23 mm.

ing expiration, when the intra-alveolar pressure rises, the size of the vessels decreases due to compression. Westermarck⁶ states that in normal subjects a positive intra-alveolar pressure of 40 cm. of water, or approximately 30 mm. of mercury, is required to compress the central branches of the pulmonary artery. Our study quite

agrees with Westermarck's observations. An apparent increase in measurement of the right descending pulmonary artery during inspiration and a decrease during expiration was noted in all 1,085 normal subjects. The range of difference of inspiratory and expiratory measurements was 1 to 3 mm. The difference was 2 mm. in 748 cases (69

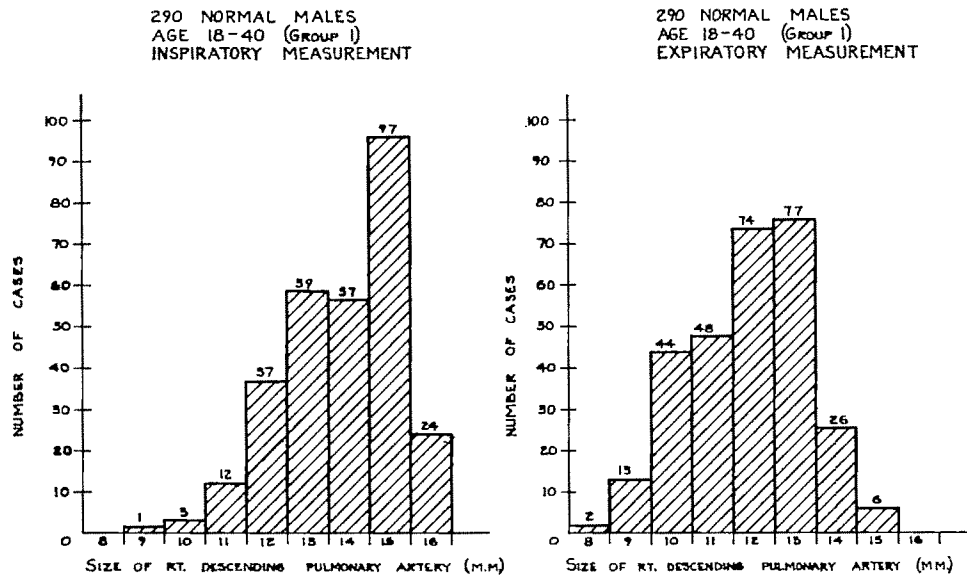


FIG. 4. Inspiratory and expiratory measurements of the right descending pulmonary artery in Group I.

per cent). Westermarck explained that the differences in the intra-alveolar pressure during respiration depend on the elasticity of the lungs. Macklin⁴ also found that the varying size of the pulmonary vessels during respiration is based on lung elasticity.

This author noted that an increase in the size of the right descending pulmonary artery during expiration occurs in pulmonary hypertension (Fig. 3, A, B and C). This will be the subject of a future communication. The inspiratory and expiratory meas-

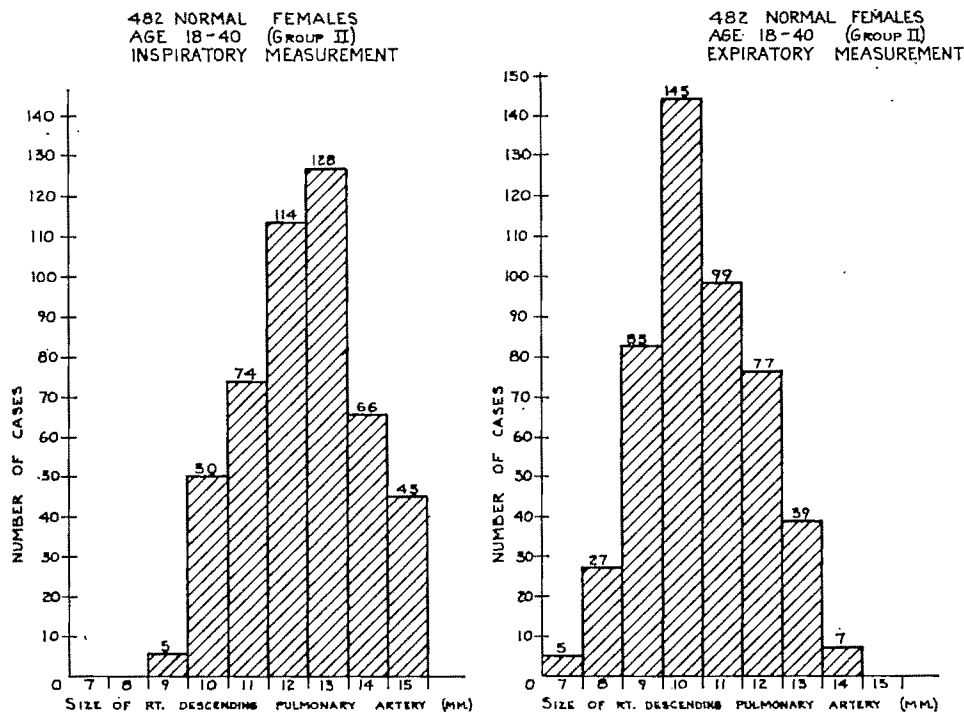


FIG. 5. Inspiratory and expiratory measurements of the right descending pulmonary artery in Group II.

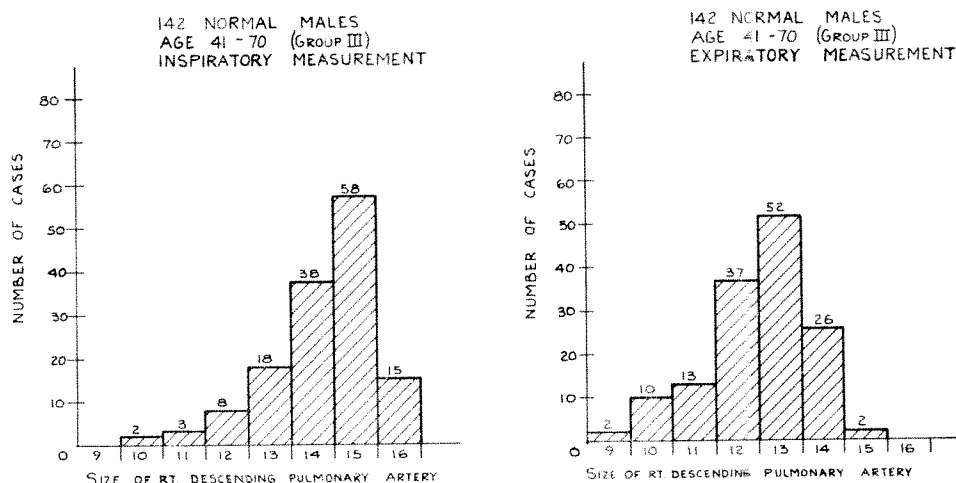


FIG. 6. Inspiratory and expiratory measurements of the right descending pulmonary artery in Group III.

urements are of great value, especially in borderline normal cases. In normal cases, there is a definite decrease during expiration. This phenomenon of increase in size of the right descending pulmonary artery during expiration in pulmonary hypertension is interesting and probably is the result of a higher pulmonary artery pressure than intra-alveolar pressure and a further increase of the pressure in the pulmonary artery due to compression of the pulmonary capillaries during expiration. However, some unknown factors may be involved and further studies are necessary to elucidate this matter.

The literature concerning the roentgeno-

graphic measurements of the right descending pulmonary artery has been reviewed. The findings of the present study agree with those of Abrams.¹ However, there is definite disagreement with the opinions of Assmann,² though his roentgenograms were made at 1.5 meters, Johnson *et al.*,³ and Schwedel *et al.*⁵ There was not a single case exceeding 17 mm. in measurement of the right descending pulmonary artery in 1,085 normal subjects of the present group. However, in 39 normal males the inspiratory measurement was 16 mm. and this figure exceeds the normal upper limits of 14 mm. to 15 mm. proposed by Assmann,² Johnson *et al.*,³ and Schwedel *et al.*⁵

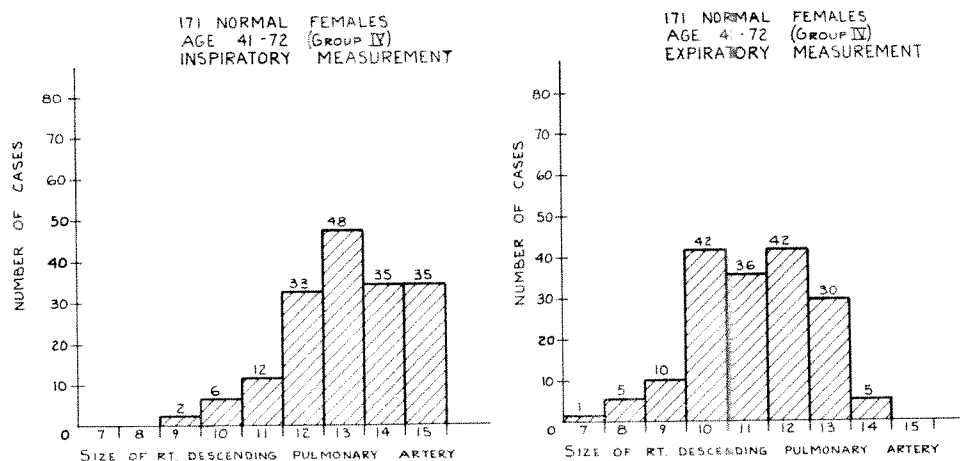


FIG. 7. Inspiratory and expiratory measurements of the right descending pulmonary artery in Group IV.

The measurement in the normal adult female group never exceeded 15 mm. The largest expiratory measurement for the normal adult males was 15 mm. as compared to 14 mm. for the normal adult females. The smallest inspiratory measurement was 9 mm. for both males and females. The smallest expiratory measurement for the males was 8 mm. and for the females 7 mm.

SUMMARY AND CONCLUSIONS

The normal roentgenographic inspiratory and expiratory measurements of the right descending pulmonary artery in 1,085 adult subjects are presented. To my knowledge this is the first report of expiratory measurements of the right descending pulmonary artery. On the basis of this study, the following conclusions may be drawn:

1. The normal upper limit for the inspiratory measurement of the right descending pulmonary artery of normal male adults is 16 mm. If the right descending pulmonary artery measures 17 mm. or more, it is abnormal and pulmonary hypertension is most likely present.
2. The normal upper limit for the inspiratory measurement of the right descending pulmonary artery of normal female adults is 15 mm. If this measures 16 mm. or more, pulmonary hypertension is most likely present.
3. There are apparent changes in the measurement of the right descending pulmonary artery during respiration in normal adults. During inspiration, when the intra-alveolar pressure falls, the size of the right descending pulmonary artery increases and during expiration, when the intra-alveolar pressure rises, the size of the vessel decreases due to compression. There are 1 to 3 mm. differences between inspiratory and expiratory measurements. In 69 per cent of the cases, the difference was 2 mm.
4. The expiratory measurement is helpful, especially, in borderline cases. In

pulmonary hypertension the expiratory measurements tend to exceed the inspiratory measurements. However, in normal cases the expiratory measurement is always smaller than the inspiratory measurement.

5. Though there is a wide range of variation in the measurements of normal individuals, a slightly greater mean measurement is noted in males, older groups (over 41 years of age) and taller and heavier subjects (over 6 feet and over 200 pounds).

6. In a future communication the normal findings will be compared with those noted in pulmonary embolism with infarction.

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ROENTGENOGRAPHIC PREDICTION OF PULMONARY HYPERTENSION IN MITRAL STENOSIS

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MITRAL stenosis produces changes in the heart and lungs varying from no alterations to all degrees of abnormalities. These changes develop in the following order: left atrium, pulmonary veins, capillaries of the lung, pulmonary arteries, right ventricle and right atrium. Therefore pulmonary venous, capillary, and arterial hypertension may be encountered and each manifests itself with different clinical and roentgenographic findings.^{4,9,10,12,29}

When significant *pulmonary venous hypertension* develops in mitral stenosis, it is manifested by normal or narrowed pulmonary veins in the lower lung fields, prominent pulmonary veins in the upper lung fields, and dilated veins in the hili.^{26,28} This is seen to best advantage in frontal laminagrams⁸ and in pulmonary angiograms,¹ although it is usually recognizable in the plain chest roentgenogram¹⁵ (Diagram 1; and Fig. 1 and 2). Ill-defined or irregular upper and outer margins of the root shadows at the hilus and obliteration of the right paracardiac space may also be noted.

Evidence of *capillary hypertension* will express itself by all or several of the following: presence of Kerley's B and A lines; perivascular haziness; prominent reticulation in the lower lobes (lobular pattern), and loss of translucency in the bases. These findings are probably due to interstitial pulmonary edema. Thickening of the interlobar fissures and obliteration of the costophrenic sulci may also occur.¹⁴ Progression of edema into the intra-alveolar phase produces ill-defined shadows in the lung, which may be widespread, confluent, unilateral, bilateral, symmetric or asym-

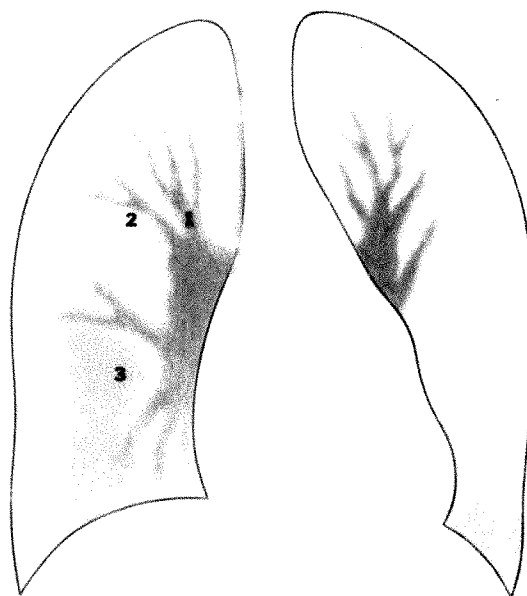


DIAGRAM 1. *Pulmonary venous hypertension in mitral stenosis*: 1—prominent upper lobe veins; 2—poor delineation of upper lobe pulmonary veins; 3—paracardiac haziness.

metric in appearance and distribution²¹ (Diagram 2).

Pulmonary arterial hypertension will be reflected by all or several of the following: straightening or bulging of the pulmonary artery segment; prominent sharp hilar shadows due to increase in caliber of the right and left pulmonary arteries; dilated pulmonary arteries in the upper lobes, narrowing of pulmonary arteries in the lower lobes, middle lobe, and lingula; tortuosity of the intrapulmonary arteries; and decreased vascularity in the peripheral lung fields^{2,11,13,19,23,25} (Diagram 3).

Pulmonary vascular and parenchymal

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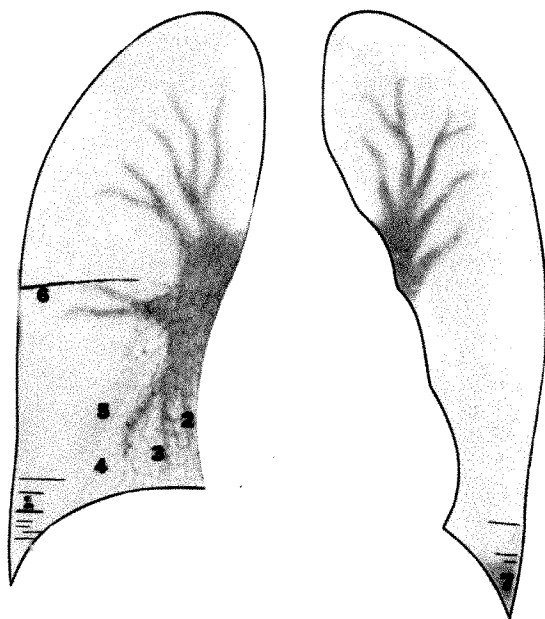


DIAGRAM 2. *Pulmonary capillary hypertension in mitral stenosis*: 1—costophrenic septal lines (Kerley's B lines); 2—indistinct heart border; 3—ill-defined lower lobe vessels; 4—prominent reticular pattern (lobular pattern); 5—haziness of the lower lobes; 6—interlobar effusion; 7—blunting of costophrenic angle.

changes may be absent with minimally altered hemodynamics. Some or all of the abnormal findings that are shown in our diagrams may occur independently but more often in combination: 1 and 2; 1, 2 and 3; and 1 and 3.

Several papers have been published outlining the criteria for predicting roentgenographically the degree of pulmonary arterial hypertension.^{7,17,18,20,30} The analysis of all of the pulmonary vascular changes is believed to be a more accurate procedure than the consideration of a small group of isolated features. A study has been carried out to determine the validity of this assumption.

METHOD

A group of posteroanterior roentgenograms of the chest of 107 patients with mitral stenosis was studied (cases from the Cardiovascular Institute of Havana). All patients had the diagnosis of mitral stenosis confirmed at surgery; all had had right

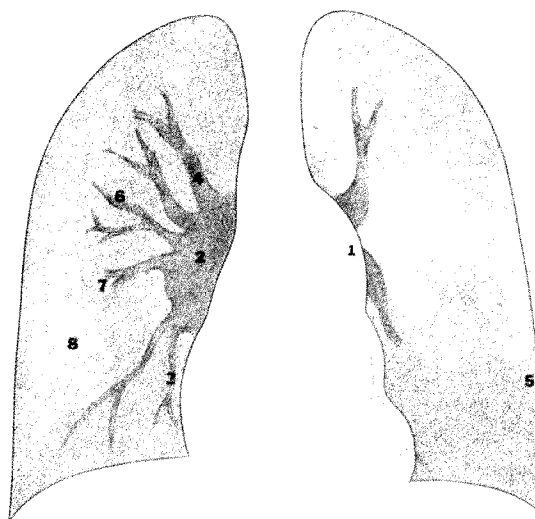


DIAGRAM 3. *Pulmonary arterial hypertension in mitral stenosis*: 1—bulging of pulmonary artery segment; 2—dilated hilar arteries; 3—constricted lower lobe vessels; 4—dilated upper lobe vessels; 5—peripheral hypovascularity; 6—tortuosity of intrapulmonary arteries; 7—abrupt narrowing of intrapulmonary arteries; 8—diffuse granularity (hemosiderosis) found occasionally.

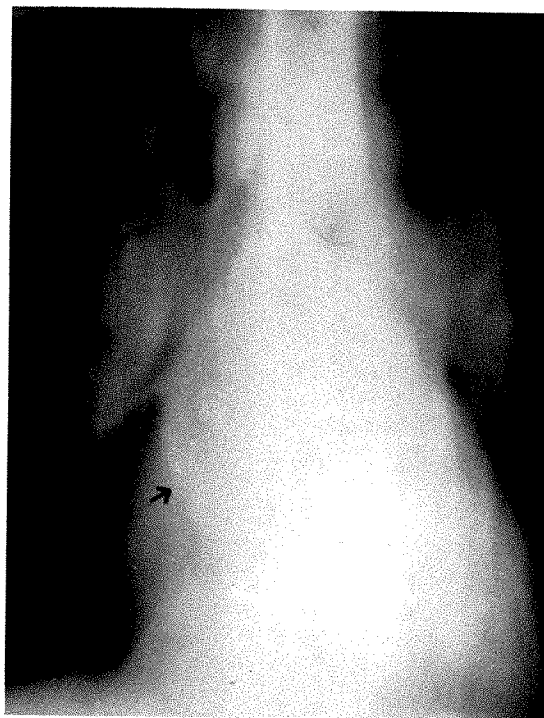


FIG. 1. Mitral stenosis. Frontal laminagram showing prominent hilar arteries and upper lobe vessels with narrowing of the lower lobe vessels.

TABLE I
SUMMARY OF THE FINDINGS OF PULMONARY ARTERIAL HYPERTENSION

Roentgenographic Analysis of:	Group I	Group II	Group III	Group IV
1. Pulmonary artery segment (PAS)				
a. Concave	Usually	Never	Never	Never
b. Straight	Occasionally	Usually	Occasionally	Never
c. Convex	Seldom	If present, not more than 5 mm.	If present, 3 to 7 mm.	Between 3 and 12 mm.
2. Distance from midline to the external border of the right hilar shadow	Within normal limits	Not more than 5.7 cm.	From 5.5 to 6.5 cm.	From 5.5 to 7 cm.
3. Diameter of the right lower lobe pulmonary artery	Normal 9 to 14 mm.	1 to 1.5 cm.	2 to 3 cm.	2 to 3 cm.
4. Narrowing of the pulmonary vessels of the lower lobes	Present or absent	Present	Present	Present
5. Prominence of the pulmonary vessels of the upper lobes	Not prominent	Slightly prominent	Moderately prominent	Moderately or markedly prominent
6. Abrupt narrowing of the intrapulmonary arteries	Not present	Not present, or when present, in the peripheral half of the lungs	Not present, or when present, in mid portion or outer peripheral half of the lungs	Present, in mid portion or in medial half of the lungs
7. Tortuosity of the intrapulmonary vessels	Not present (in preoperative cases)	Not seen (in preoperative cases)	Sometimes seen	Frequently noted
8. Abnormal peripheral, bilateral hypovascularity	Not present	Not present	Present in outer $\frac{1}{3}$, $\frac{1}{2}$ or $\frac{2}{3}$ of the lungs	Present in outer $\frac{1}{3}$ or $\frac{2}{3}$ of the lungs

heart catheterization and roentgenograms of the chest were made within two days of the time of catheterization.

The roentgenograms were read without knowledge of the clinical or catheterization findings. Each film was graded for the absence or presence of the following criteria (Table I):

1. The pulmonary artery segment of the left cardiac border.
2. The distance from the midline to the external aspect of the right hilar shadow.
3. The diameter of the right lower pulmonary artery just below its origin.
4. The appearance of the pulmonary vessels of the lower lobes.
5. The degree of prominence of the pulmonary vessels of the upper lobes.
6. The evidence of abrupt narrowing of the intrapulmonary arteries and, if present, the place where it occurred.
7. Tortuosity of the intrapulmonary vessels.
8. The vascularity of the periphery of the lungs.
9. The presence or absence of Kerley's B and A lines and of perivascular haziness.
10. The presence or absence of pulmonary hemosiderosis.



FIG. 2. Mitral stenosis. Angiocardiogram (levo phase). Moderately enlarged left atrium with prominence of the pulmonary veins of the upper lobes.

TABLE II

SUMMARY OF THE GROUPS OF CASES WHICH WERE STUDIED; PULMONARY ARTERIAL HYPERTENSION

	Group I	Group II	Group III	Group IV
1. Number of preoperative roentgenograms	11	27	29	18
2. Number of postoperative roentgenograms	2	9	5	6
3. Total number of roentgenograms	13	36	34	24
4. Degree of accuracy	69.23% (9 of 13)	75% (27 of 36)	76.47% (26 of 34)	87.5% (21 of 24)

The roentgenograms were then grouped in four categories based on the mean pulmonary artery pressure recorded at the time of catheterization and the above diagnostic criteria were tabulated and evaluated for each category⁶ (Table II). The categories based on mean pulmonary artery pressure were:

- Group I. Absent pulmonary arterial hypertension: pulmonary artery mean pressure of less than 20 mm. of mercury.
- Group II. Minimal pulmonary arterial hypertension: pulmonary artery mean pressure between 21 and 34 mm. of mercury.
- Group III. Moderate pulmonary arterial hypertension: pulmonary artery mean pressure between 35 and 54 mm. of mercury.
- Group IV. Severe pulmonary arterial hypertension: pulmonary artery mean pressure greater than 55 mm. of mercury.

The roentgenographic criteria described above were then evaluated for correlation with the grouping based on pulmonary artery pressure readings (Table II).

In Group I (13 roentgenograms, 2 were postoperative chest roentgenograms) either the chest was normal in the posteroanterior view (Fig. 3) or minimal pathologic changes were present. These abnormalities consisted of left atrial enlargement and occasional narrowing of the pulmonary vessels of the lower lobes associated with prominent or normal appearing pulmonary vessels of the upper lobes.

In Group II (36 roentgenograms, 9 were postoperative chest roentgenograms) the

pulmonary artery segment was straight or convex (not more than 5 mm.). The distance from the midline to the external border of the right hilar shadow was not more than 5.7 cm. The right lower pulmonary artery was 1 to 1.5 cm. in diameter. Narrowing of the pulmonary vessels of the lower lobes was usually present. Prominence of the vessels of the upper lobes was a frequent finding. Abrupt narrowing of the intrapulmonary arteries was either not noted or, when seen, occurred in the exter-

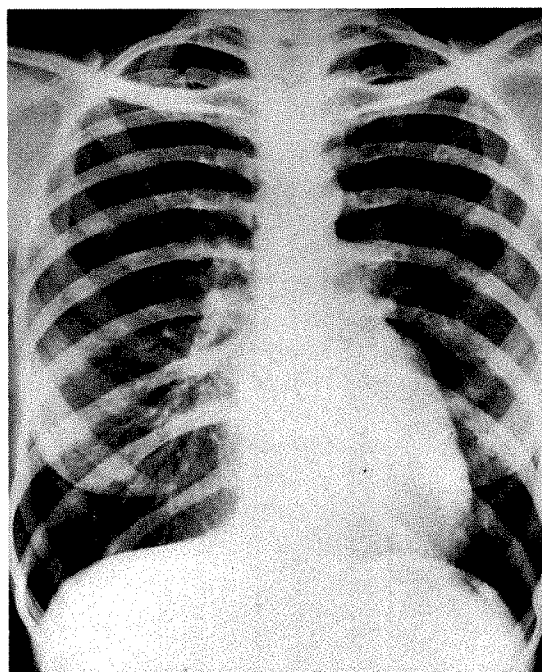


FIG. 3. Mitral stenosis with absent pulmonary arterial hypertension. Pulmonary artery pressure: systolic 30, diastolic 14, mean 20; pulmonary capillary pressure 11. There is prominence of the left auricular appendage and normal appearing pulmonary vasculature.

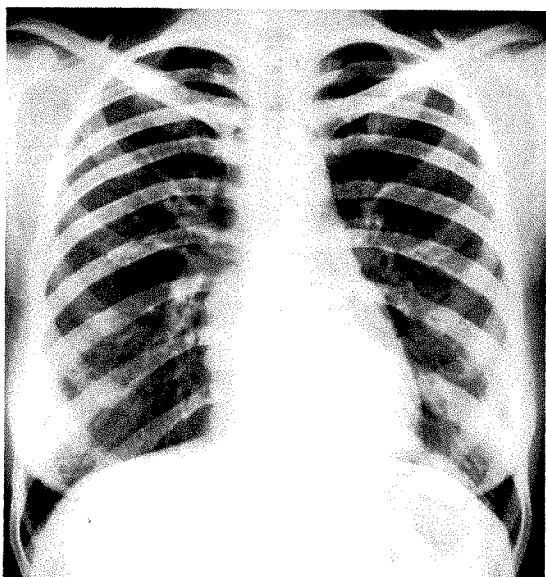


FIG. 4. Mitral stenosis with minimal pulmonary arterial hypertension. Pulmonary artery pressure: systolic 38, diastolic 18, mean 26; pulmonary capillary pressure 20. There is straightening of the pulmonary artery segment and slight dilatation of the right and left pulmonary arteries. Narrowing of the pulmonary vessels of the lower lobes and prominence of the pulmonary vessels of the upper lobes are noted.

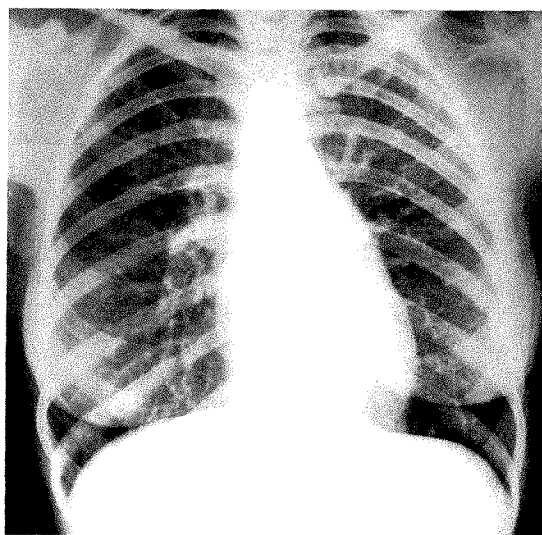


FIG. 5. Mitral stenosis with minimal pulmonary arterial hypertension. Pulmonary artery pressure: systolic 42, diastolic 25, mean 28; pulmonary capillary pressure 15. There is slight convexity of the left middle arch. The right pulmonary artery is slightly prominent. Slight prominence is noted of the medial vessels in the left upper lobe.

nal half of the lung fields. Tortuosity of the intrapulmonary vessels was not usually present and abnormal peripheral hypovascularity was never noted. Kerley's B lines were seen in 22 per cent of the roentgenograms and the majority of these were postoperative studies. Neither hemosiderosis nor intrapulmonary ossification was seen (Fig. 4, 5 and 6).

In Group III (34 roentgenograms, 5 were postoperative chest roentgenograms) the pulmonary artery segment was straight or convex (3 to 7 mm.). The distance from the midline to the external border of the right hilar shadow was between 5.5 and 6.5 cm. The pulmonary artery of the right lower lobe had a diameter between 2 and 3 cm. Narrowing of the pulmonary vessels of the lower lobes was invariably present. The pulmonary vessels of the upper lobes were either symmetric or asymmetric and moderately prominent. The prominence was occasionally greater on the left side

than on the right side. Abrupt narrowing of the intrapulmonary arteries was not often apparent and, when noted, occurred in the mid portion or in the outer half of the lung fields. Tortuosity of the intrapulmonary vessels was not frequently observed. Hypovascularity of the periphery of the lungs was seen in the external one third, one half, or two thirds. Kerley's B lines were seen in 44 per cent of the roentgenograms. Hemosiderosis was an infrequent finding. Intrapulmonary ossification was occasionally noted (Fig. 7, 8 and 9).

In Group IV (24 roentgenograms, 6 were postoperative chest roentgenograms) the pulmonary artery segment was always convex (3 to 12 mm.) except in one case where a straight pulmonary artery segment was found. The distance from the midline to the external border of the right hilar shadow was between 5.5 and 7 cm. The pulmonary artery of the right lower lobe had a diameter between 2 and 3 cm. Narrowing of the pulmonary vessels of the lower lobes was a constant finding. The vessels of the upper lobes were usually moder-

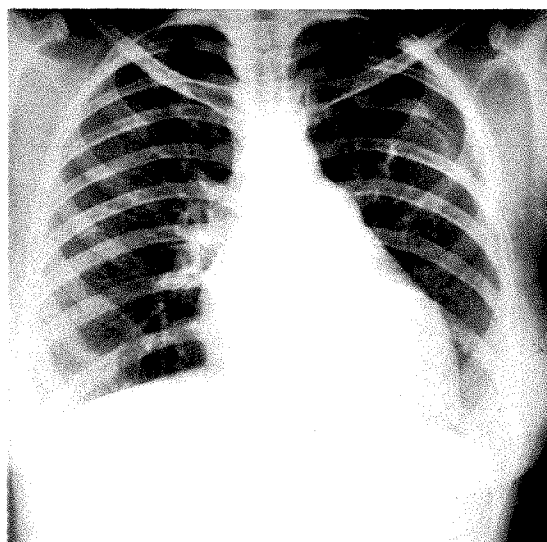


FIG. 6. Mitral stenosis with minimal pulmonary arterial hypertension. Postoperative roentgenogram. Pulmonary artery pressure: systolic 48, diastolic 27, mean 32; pulmonary capillary pressure 14. There is moderate cardiomegaly and slight convexity of the pulmonary artery segment. The pulmonary arteries are moderately prominent. There is slight narrowing of the pulmonary vessels in the lower lobes and there are slightly prominent vessels in the upper lobes.

ately or markedly prominent. This feature was seen unilaterally, as well as bilaterally, and was more often demonstrated on the left side. Abrupt narrowing, when noted, was present in the mid portion or in the medial half of the lung fields. Tortuosity of the intrapulmonary vessels was frequently encountered. Abnormal peripheral hypovascularity was usually seen in the external half or two thirds of the lungs. Kerley's B lines were observed in 48 per cent of the roentgenograms. Kerley's A lines, in addition to B lines, were occasionally present (Fig. 10, 11, 12 and 13). Hemosiderosis or intrapulmonary ossification was seen infrequently (Fig. 14 and 15).

There was an over-all degree of efficacy of 77 per cent in the prediction of the degree of pulmonary arterial hypertension from the 107 roentgenograms (first series): 80 per cent accuracy was achieved by studying the 85 preoperative roentgenograms and 64 per cent accuracy by study-

ing the 22 postoperative roentgenograms. The degree of inaccuracy in the evaluation of postoperative roentgenograms was probably due to the fact that hemodynamics improved rapidly while the change in the appearance of the lung vessels and heart was usually at a slower pace. The anatomic changes in some cases either showed only a slight modification or never returned to a normal appearance. There was greater correlation when the postoperative roentgenograms were evaluated six months to a year after surgery than when the evaluation was made close to the time of surgery.

The higher the mean pulmonary artery pressure, the greater the proficiency of the roentgenographic interpretation.

DISCUSSION

This study indicates that by utilizing the diagnostic criteria in Table 1, the radiologist can estimate the degree of pulmonary arterial hypertension in mitral stenosis with a high degree of accuracy. No single diagnostic sign is reliable in itself but by evaluating *qualitatively* the posteroanterior chest roentgenograms for the ten criteria defined above, a more reliable conclusion is obtained by such a total evaluation of all available evidence of pulmonary hypertension.

Pulmonary arterial hypertension manifests itself in the heart (posteroanterior roentgenogram) by straightening or bulging of the pulmonary artery segment (PAS) which is the superior part of the left middle arch.^{16,27} However, straightening or bulging of the pulmonary artery segment does not necessarily mean pulmonary arterial hypertension. Several studies have shown no absolute correlation between the degree of prominence of the PAS and the degree of pulmonary arterial hypertension. In the evaluation of the degree of pulmonary arterial hypertension, the analysis of the PAS is one of several diagnostic aspects to be considered, but should not be regarded by itself as the most important feature.

In cases with significant pulmonary arterial hypertension, prominence of the pul-

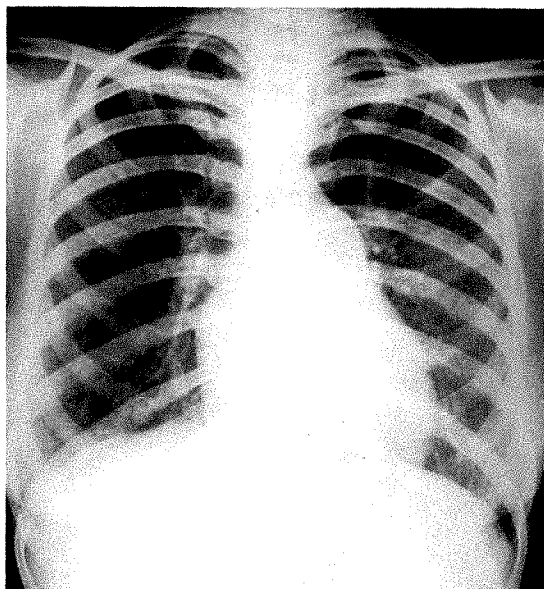


FIG. 7. Mitral stenosis with moderate pulmonary arterial hypertension. Pulmonary artery pressure: systolic 57, diastolic 36, mean 41; pulmonary capillary pressure 22. There is a moderately convex pulmonary artery segment. Slight prominence of the vessels in the left upper lobe with narrowing of the pulmonary vessels in the right lower lobe is noted. Slight peripheral hypovascularity is present.

monary arteries in the hilar regions is usually seen. An indirect manner of evaluating this finding is by measuring the distance from the midline to the external border of the right hilus and by measuring, when possible, the diameter of the right lower pulmonary artery just below its origin. Body build, scoliosis, emphysema, pulmonary edema, degree of inspiration, and cardiomegaly are factors which should be taken into account when making this determination. Frontal laminagrams are ideal for this purpose.

When pulmonary arterial hypertension and/or pulmonary venous hypertension of a significant degree develops in mitral stenosis, narrowing of the pulmonary vessels of the lower lobes may be seen. There is, in addition, evidence of normal-to-abnormal prominent pulmonary vessels of the upper lobes, best observed in the medial aspect of both upper lobes on frontal laminagrams. When asymmetry of the upper lobes vasculature is noted, we have found

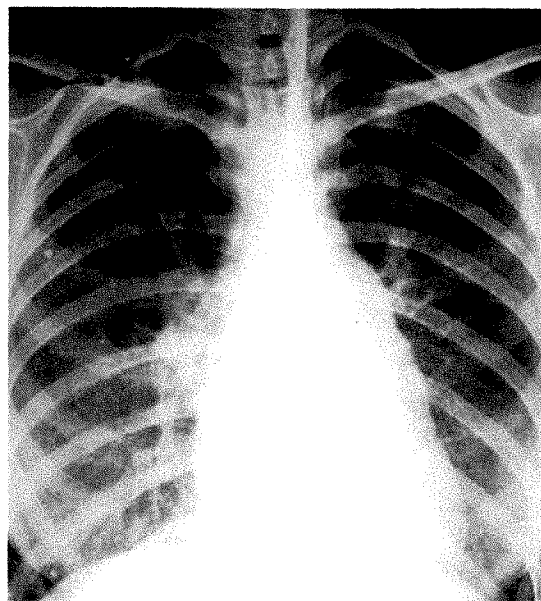


FIG. 8. Mitral stenosis with moderate pulmonary arterial hypertension. Pulmonary artery pressure: systolic 67, diastolic 36, mean 47; pulmonary capillary pressure 46. The pulmonary artery segment is slightly convex. The right pulmonary artery as well as the pulmonary vessels in both upper lobes are moderately prominent. There is narrowing of the pulmonary vessels in the right lower lobe. Peripheral pulmonary hypovascularity is noted in the outer two thirds of the lungs. Kerley's B lines are seen in the right costophrenic angle.

that the vessels in the left upper lobe are usually more prominent than the ones in the right upper lobe. Generally, the degree of prominence of the pulmonary vasculature of the upper lobes parallels the severity of pulmonary hypertension. However, the discrepancy between the upper and lower lobe pulmonary vessels is not always indicative of pulmonary hypertension and should not be an isolated finding on which to base the diagnosis.

Abrupt narrowing of intrapulmonary arteries may be due to obstruction or to vasoconstriction. In moderate or severe pulmonary arterial hypertension, this is a frequent finding. It correlates with the degree of pulmonary arterial hypertension. Tortuosity of the intrapulmonary vessels is occasionally noted, being most likely related to long standing pulmonary hypertension. It may be the expression of sclerot-

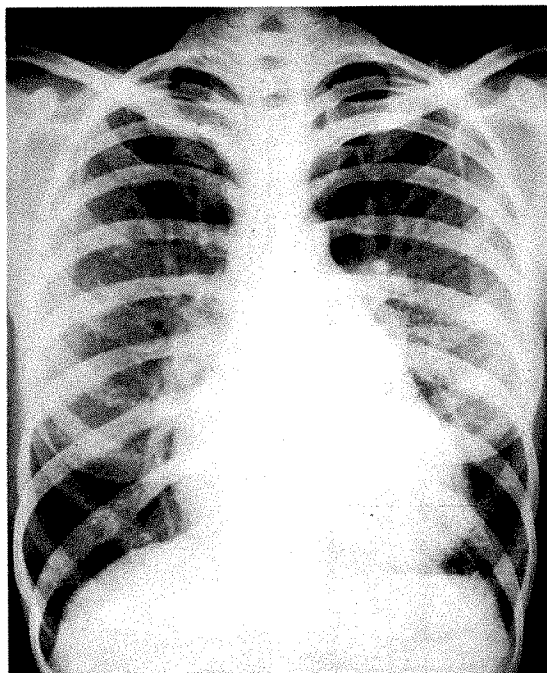


FIG. 9. Mitral stenosis with moderate pulmonary arterial hypertension. Pulmonary artery pressure: systolic 53, diastolic 24, mean 43; pulmonary capillary pressure 25. There is moderate cardiomegaly and slight prominence of the pulmonary artery segment. Both pulmonary arteries are markedly enlarged. There is narrowing of the pulmonary vessels of the lower lobes and moderate prominence of the pulmonary vessels of the upper lobes. Peripheral bilateral hypovascularity is noted in the outer third of the lungs.

ic changes in the pulmonary vascular tree. This finding can also be encountered in severe left-to-right shunts or when they have been present several years.

Abnormal, bilateral, peripheral hypovascularity of the lungs¹¹ probably is secondary to diffuse pulmonary arterial or arteriolar narrowing and usually indicates, according to its extension, the presence of moderate or severe pulmonary arterial hypertension.

The significance of the presence of Kerley's B lines has been a subject of several publications.^{5,22} These basal, horizontal, parallel, sharp, short, non-bifurcated, septal lines are said to be present when there is edema of the interlobular septa between the secondary lobules in the vicinity of the costophrenic angles (transient Kerley's B

lines). They may also be due to fibrosis, with or without deposit of particles, such as hemosiderin (permanent Kerley's B lines). These basal septal lines are diagnostically nonspecific and in mitral stenosis can be either transient or permanent. Transient Kerley's B lines in mitral stenosis indicate severe pulmonary venous and capillary hypertension.²⁸ In our first series, Kerley's B lines were present on 35 roentgenograms. When transient Kerley's B lines were noted, the pulmonary wedge pressure was usually 30 mm. of mercury or higher, and moderate or severe pulmonary arterial hypertension was present. Perivascular haziness and a prominent reticular pattern were seen with or without Kerley's B lines and indicated severe pulmonary veno-capillary hypertension.

Hemosiderosis was uncommonly present and intrapulmonary ossification nodules were noted only twice.

EVALUATION

To test the reliability of the criteria for grading pulmonary arterial hypertension, a new collection of test films was made by obtaining the roentgenograms of 25 cases from a second institution (Jackson Memorial Hospital) and of 25 cases from a third institution (National Children's Cardiac Hospital). The catheterizations were performed in each respective institution by different operators. This group of 50 cases was then evaluated by 5 senior radiologists and 2 third year residents, using the criteria set forth in Table 1. No clinical information was given to the readers except that the patients all had mitral stenosis. The results of this test are summarized in Table III.

No reader graded any case more than one category from the correct catheterization category except two readers, who each graded one case different by two categories.

SUMMARY AND CONCLUSION

In cases of mitral stenosis with pulmonary hypertension, narrowing of the pulmonary vessels of the lower lobes is practically always noted.

TABLE III
SUMMARY OF READERS' PROFICIENCY IN DESIGNATING CORRECT CATEGORY OF MEAN
PULMONARY ARTERY HYPERTENSION OF TEST GROUP OF CASES
(Per Cent)

Reader	1	2	3	4	5	6	7
Correct category designated	77	67	69	65	65	79	79
Correct within one category	100	100	96	96	100	100	100
Over-all degree of accuracy	71.5						

Minimal pulmonary arterial hypertension is suggested when several of the following findings are present: 1. straight pulmonary artery segment or with a convexity not greater than 5 mm.; 2. slight prominence of the pulmonary vessels of the upper lobes; and 3. abrupt narrowing of the intrapulmonary vessels seen in the peripheral half of the lungs.

Moderate pulmonary arterial hypertension may be predicted when most of the following features are present: 1. a pulmo-

nary artery segment with a convexity of 3 to 7 mm. or occasionally straight; 2. moderately prominent pulmonary arteries in the hilar regions; 3. moderately prominent pulmonary vessels of the upper lobes; 4. abrupt narrowing of the intrapulmonary arteries in the mid portion or in the peripheral half of the lungs; 5. abnormal peripheral, bilateral, hypervascularity in the outer third, half or two thirds of the lungs; and 6. fre-

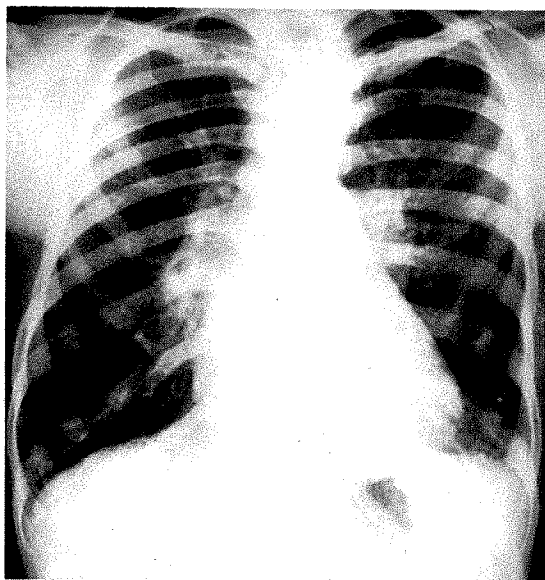


FIG. 10. Mitral stenosis with severe pulmonary arterial hypertension. Pulmonary artery pressure: systolic 90, diastolic 47, mean 58; pulmonary capillary pressure 44. There is slight convexity of the pulmonary artery segment. Both pulmonary arteries are markedly prominent. Peripheral lung hypovascularity is noted in the outer half. Kerley's B lines are present bilaterally and there is blunting of both costophrenic angles.

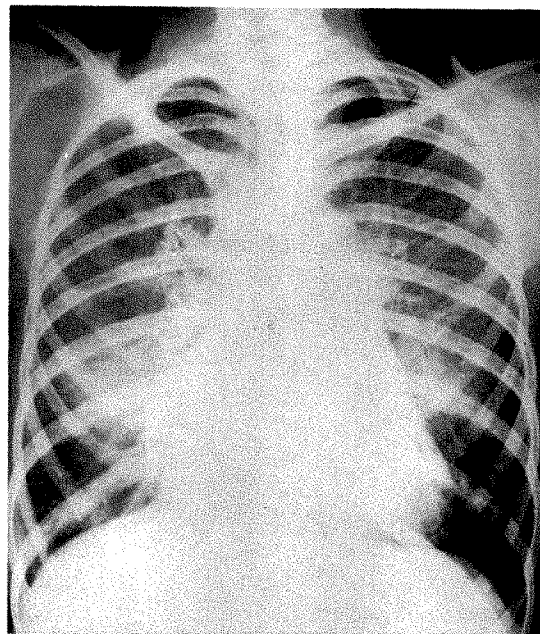


FIG. 11. Mitral stenosis with severe pulmonary arterial hypertension. Pulmonary artery pressure: systolic 139, diastolic 69, mean 100. There is moderate cardiomegaly. The pulmonary artery segment and the right atrial border as well as the pulmonary vessels of the upper lobes are moderately prominent. Ill-defined haziness is noted in the parahilar regions representing pulmonary edema.

quent presence of Kerley's B lines.

Severe pulmonary arterial hypertension may be suspected when most of the following features are present: 1. a pulmonary segment with a convexity of 3 to 12 mm.; 2. moderately or markedly prominent pulmonary arteries in the hilar regions; 3. moderately or markedly prominent pulmonary vessels in the upper lobes; 4. abrupt narrowing of the intrapulmonary arteries in the mid portion or in the medial half of the lungs; 5. frequent occurrence of tortuosity of the intrapulmonary arteries; 6. abnormal peripheral, bilateral, hypovascularity in the outer half or two thirds of the lung; and 7. frequent presence of Kerley's B lines.

One hundred and seven roentgenograms of the chest of patients with mitral stenosis were studied for evidence of ten roentgenographic signs. The accuracy of these was correlated with mean pulmonary artery pressure at the time of catheterization to

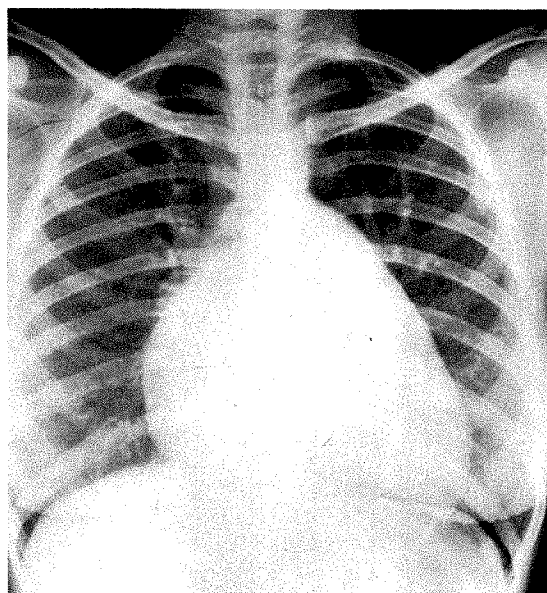


FIG. 12. Mitral stenosis with pulmonary arterial hypertension. Pulmonary artery pressure: systolic 138, diastolic 78, mean 107. There is marked cardiomegaly with marked convexity of the pulmonary artery segment. There is slight prominence of the pulmonary vessels in both upper lobes. The outstanding feature is the peripheral hypovascularity of the lungs which is present in the outer two thirds.

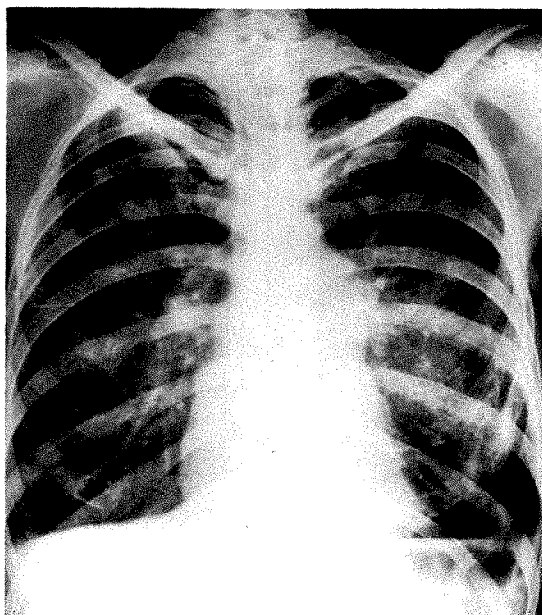


FIG. 13. Mitral stenosis with severe pulmonary arterial hypertension. Pulmonary artery pressure: systolic 85, diastolic 40, mean 71. The pulmonary artery segment is moderately convex. The right and left pulmonary arteries are moderately prominent. Peripheral hypovascularity is noted in the outer two thirds of the lungs. A fine stippling is present throughout both lung fields which represents hemosiderosis.

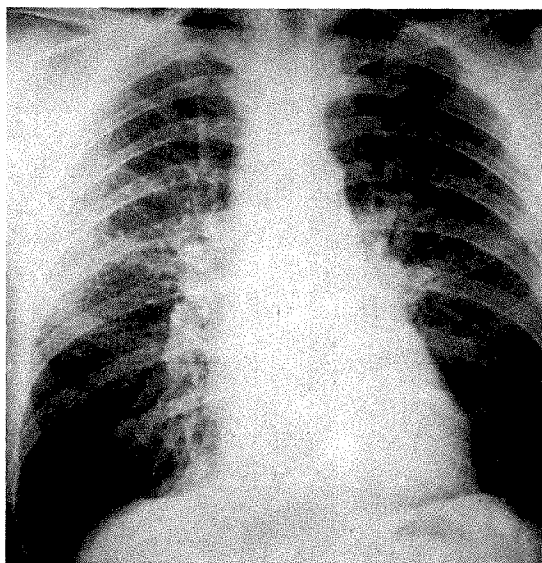


FIG. 14. Mitral stenosis with severe pulmonary arterial hypertension and hemosiderosis.

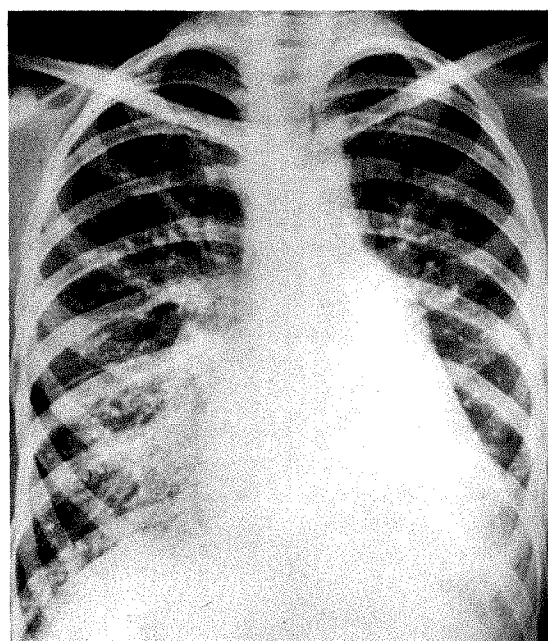


FIG. 15. Mitral stenosis with severe pulmonary arterial hypertension and intrapulmonary ossification nodules.

prepare a guide for prediction of the degree of pulmonary arterial hypertension from the posteroanterior chest roentgenogram.

Applying these criteria, 50 additional cases of mitral stenosis were studied by seven radiologists and good correlation was found between the readers' prediction and catheterization pressure readings.

Several diagnostic criteria must be fulfilled in order to diagnose and grade pulmonary arterial hypertension roentgenographically. It is thought that reliance upon a single or a few diagnostic features and/or their numerical expression is less accurate than the *qualitative evaluation* of several features.

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ROENTGEN FEATURES OF RHEUMATIC TRICUSPID STENOSIS*

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IN THE past there has been considerable dispute regarding the frequency and diagnosis of disease of the tricuspid valve. Apparently, Durosiez,¹⁴ in 1868, was the first to describe in detail 10 cases of tricuspid stenosis proved by autopsy. Despite this, almost fifty years later Osler and Gibson²⁸ stated: "As a rule the physician is in a safer position if he limits his diagnosis to 2 valves. Clinically, when lesions of 3 or 4 valves are determined with accuracy, mortifying postmortem disclosures are not unlikely to follow." As late as 1928, Strümpell and Seyfarth³⁹ remarked that tricuspid stenosis was so rare that it was of no practical importance as a clinical entity. This is in marked contrast to more recent reports wherein the incidence of significant tricuspid stenosis varied from 5 to 14 per cent in large series of autopsied cases of rheumatic heart disease.^{9,17,18,34,41,42} Cooke and White⁹ found an incidence of 14 per cent at autopsy in 217 cases of rheumatic heart disease while Garvin¹⁷ reported an incidence of 11 per cent in 119 consecutive patients who died of rheumatic heart disease. In 1958, Wallach and Angrist,⁴¹ in a review of 8,676 consecutive necropsies at Queens General Hospital, New York City, covering the period from 1936 to 1950, found 282 cases of severe rheumatic mitral or aortic stenosis, or both concurrently. The mitral valve alone was involved in 168 patients (59 per cent), the aortic valve only in 33 (12 per cent), and both valves were affected in 81 (29 per cent). An additional number (5.7 per cent) had moderately severe or severe tricuspid stenosis. All of the cases of tricuspid stenosis also had involvement of at least 1 other valve, indicating that tricuspid stenosis in rheumatic heart

disease is essentially a multivalvular lesion.

The purpose of this paper is to report the roentgen findings in a large series of patients with proved rheumatic tricuspid stenosis in whom the diagnosis was established by cardiac catheterization, and thereby, to evaluate the roentgen diagnosis of rheumatic tricuspid stenosis. The diagnosis of rheumatic tricuspid stenosis is of practical rather than academic interest since overlooking or failure to overcome significant tricuspid stenosis at the time of mitral or aortic valvuloplasty may lead to poor postoperative results.^{29,40}

METHOD OF STUDY

The series of 20 cases of tricuspid stenosis herein reported was selected after diagnosis by cardiac catheterization, which was performed according to the techniques described by Lukas and his colleagues.^{3,22,23} Killip and Lukas^{21,22} have previously reported 12 of the 20 cases of tricuspid stenosis, but their emphasis was placed on the clinical and hemodynamic aspects. The roentgenograms of all patients were reviewed and evaluated. In addition, complete histories were obtained and thorough physical and laboratory examinations were made. All patients had multiple conventional roentgenograms of the chest, usually in frontal, lateral, left, and right anterior oblique views (Fig. 1, *A-C*; 2*A*; 3*A*; 4*A*; 5*A*; and 6, *A* and *B*). Barium studies of the esophagus in oblique and lateral views were also made in most instances. Serial angiocardiology in the erect position, in frontal and left anterior oblique views, at the rate of 1 film per second was done in 9 patients for the duration of the circulation time.¹² The method for determining the

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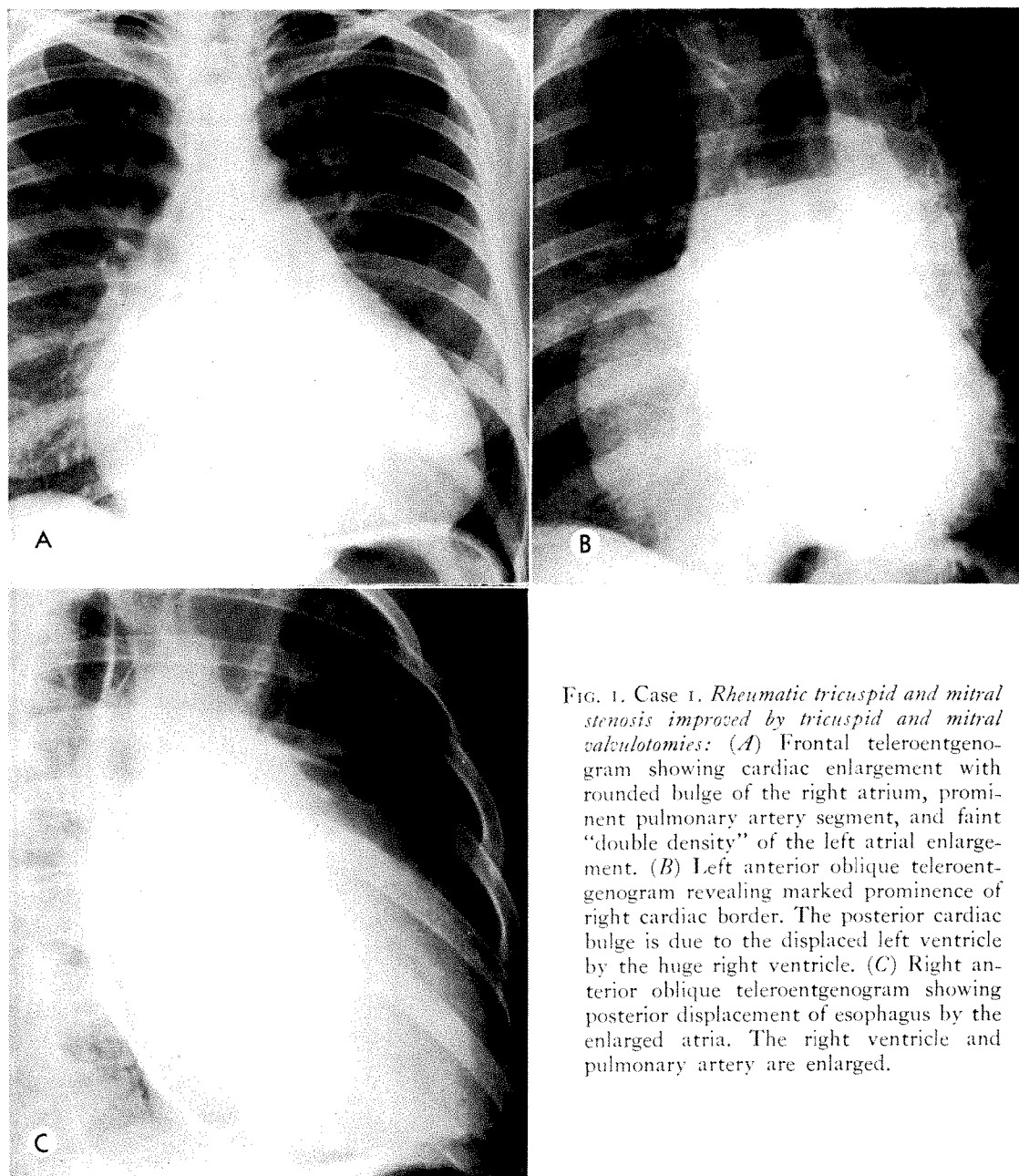


FIG. 1. Case 1. *Rheumatic tricuspid and mitral stenosis improved by tricuspid and mitral valvulotomies:* (A) Frontal teleroentgenogram showing cardiac enlargement with rounded bulge of the right atrium, prominent pulmonary artery segment, and faint "double density" of the left atrial enlargement. (B) Left anterior oblique teleroentgenogram revealing marked prominence of right cardiac border. The posterior cardiac bulge is due to the displaced left ventricle by the huge right ventricle. (C) Right anterior oblique teleroentgenogram showing posterior displacement of esophagus by the enlarged atria. The right ventricle and pulmonary artery are enlarged.

modified preliminary circulation time with decholin for abdominal aortography has recently been described.³⁷

RESULTS

The catheterization and roentgenographic data for each case of tricuspid stenosis are presented in Table I. The patients were selected because the diagnosis of tri-

cuspid stenosis had been established by cardiac catheterization. In each case there was a significant pressure gradient between the right atrium and ventricle during ventricular diastole. Killip and Lukas²² found that the diastolic right atrioventricular gradient fell to -0.1 mm. Hg¹ (S.D. ± 1.0) during exercise in patients with rheumatic heart disease without tricuspid steno-

TABLE I
CATHETERIZATION, ROENTGENOGRAPHIC, AND FOLLOW-UP DATA

Case No.	Age	Sex	Cardiac Catheterization	Conventional Roentgenograms	Angiocardiography	Surgery, Autopsy, Follow-up and Comment
1	36	F	5.1 mm. Hg diastolic gradient across T.V. Moderate pulmonary hypertension associated with M.S.	Moderate generalized chamber enlargement (Fig. 1, A-C). R.C.M. 60 mm.	Very large R.A. with prolonged opacification. Delayed filling of R.V.; T.V. shifted markedly to left. Moderate enlargement of L.A. (Fig. 1, D-F). Diameter, R.A. = 108 mm.	M. and T. valvulotomy. Moderate T.S. at operation. Doing well for the past 3 years
2	838970*	F	Diastolic gradient of 6 mm. Hg across T.V. indicating T.S. Calculated T.V. area 0.6 cm. ² . Slight T.I. and pulmonic stenosis. M.S., M.I., A.S., and A.I.	Slight S.V.C. dilatation. Huge heart (Fig. 2A). R.C.M. 70 mm.	S.V.C. slightly widened. Large R.A. measuring 80 mm. R.A. opacified for 16-17 sec. R.V., L.A., L.V. enlarged. T.V. shifted to left. Delayed filling of R.V.; P. valvular stenosis. Small pericardial effusion (Fig. 2, B-D)	M. and A. valvulotomy confirmed extensive involvement of all valves. Immediate postoperative cardiac arrest. At autopsy marked dilatation of R.A., L.A., and L.V. with stenosis of all 4 valves
3	27	M	Moderately severe M.S. 5 mm. Hg diastolic gradient on exercise across T.V. Mild T.S. not requiring valvulotomy	R.V. and L.A. enlargement (Fig. 3, A). R.C.M. 60 mm.	Slight enlargement and prolonged opacification of R.A.; T.V. not well seen. Large R.V. and L.A. (Fig. 3, B and C)	Tight M.S. repaired. No T. valvulotomy. Doing well postoperatively for past 6 months
4	705724**	F	13.2 Hg diastolic gradient across T.V. Estimated T.V. area 0.7 cm. ² . Also severe M.S.	Moderate enlargement of all chambers. Difficult to measure S.V.C. and R.A. because of dorsal scoliosis to right (Fig. 4A). R.C.M. 75 mm.	Slight widening of S.V.C. Huge right atrium opacified for 13 sec. Delayed filling of R.V.; T.V. clearly seen and shifted to left. L.A. and L.V. enlarged (Fig. 4B)	Refused surgery. Lost to follow-up
5	701068**	F	12 mm. Hg diastolic pressure gradient across tricuspid valve on exercise. Isolated T.S.	Widening of S.V.C. Heart enlarged to right. R.A. moderately enlarged (Fig. 5A). R.C.M. 72 mm.	Slightly dilated S.V.C. Large R.A. 80 mm. Continued opacification of R.A. for 6 sec. Delayed filling of R.V.; T.V. visualized and shifted to left. Remainder of heart normal (Fig. 5B)	Marked R.A. enlargement. T.V. estimated at 1.1 cm. ² . Remainder of heart normal. T. valvulotomy. Pathology sent to Aschoff bodies. Probably congenital. Doing well postoperatively for past 5 years
6	850858*	F	Marked T.S. diastolic gradient of 11.2 cm. across T.V. Probably also mild T.I., moderate to severe M.S., A.S.	Dilated S.V.C. Generalized cardiac chamber enlargement. Large R.A. (Fig. 6A). R.C.M. 65 mm.	Marked dilatation of S.V.C. Huge R.A. with prolonged opacification. T.V. clearly seen and markedly shifted to left. R.V., L.A., and L.V. enlarged (Fig. 6B). Diameter R.A. = 80 mm.	A., M. and T. valvulotomy done. Doing well for past 6 months
7	82901*	F	Trivalvular disease with stenosis and regurgitation of T., M. and A. valves. T.I. more marked than T.S.	Widening of S.V.C. Generalized cardiac chamber enlargement. R.C.M. 65 mm.	None	M. and A. valvulotomy. Findings of T.S. and T.I. confirmed. Lost to follow-up
8	550885*	M	6 mm. Hg diastolic gradient across T.V. Estimated area 1.0 cm. ² . Suggestion also of mild T.I. Also M.S. and mild A.S.	Enlargement R.A., R.V., L.A. R.C.M. 65 mm.	None	Confirmation of roentgenographic and catheter findings at surgery. M. and A. valvulotomy on Dec. 15, 1960. Doing well
9	667054**	F	5.6 mm. Hg diastolic gradient across T.V. on exercise. Also severe M.S. T.V. area calculated 1.2 cm. ²	Enlarged S.V.C., R.A., R.V., L.A. R.C.M. 80 mm.	None	M. valvulotomy in 1954. Not improved but still alive Dec., 1960
10	758436**	M	Severe T.S. with diastolic gradient across T.V. 15.6 mm. Hg on exercise. Calculated T.V. area 0.6 cm. ² . Severe M.S.	Large dilated heart with all chambers enlarged. Prominent S.V.C. R.C.M. 70 mm.	None	Died immediately preoperatively. At autopsy T.S., M.S., A.S., with marked enlargement of all chambers
11	839031*	F	Diastolic gradient 7 mm. Hg across T.V. on exercise. T.I. more marked than T.S. Severe M.S. Also mild M.I., A.S., and A.I.	Dilated S.V.C. Generalized cardiac enlargement. R.C.M. 80 mm.	None	Surgery deferred because of poor renal and pulmonary function. Alive Feb., 1961

* Hospital number.

Abbreviations: A.I. = Aortic insufficiency; A.S. = Aortic stenosis; L.A. = Left atrium; L.V. = Left ventricle; M.I. = Mitral insufficiency; M.S. = Mitral stenosis; P. = Pulmonic; R.A. = Right atrium; R.C.M. = Right cardiac measurement; R.H.D. = Rheumatic heart disease; R.V. = Right ventricle; S.V.C. = Superior vena cava; T.V. = Tricuspid valve; T.S. = Tricuspid stenosis; T.I. = Tricuspid insufficiency; M. = Mitral; T. = Tricuspid; A. = Aortic.

TABLE I—Continued

Case No.	Age	Sex	Cardiac Catheterization	Conventional Roentgenograms	Angiocardiography	Surgery, Autopsy, Follow-up and Comment
12 289189 ^{*21:29}	41	F	T.I. more severe than T.S. 19.2 mm. Hg diastolic gradient across T.V. Severe M.S.	Huge heart, all chambers enlarged. Huge R.A. displacing esophagus to the left. R.C.M. 120 mm.	Poor opacification of cardiac chambers because of markedly slow circulation time and extreme chamber dilatation. Huge R.A. measuring 130 mm. L.A. 3 times enlarged. R.V. and L.V. not well visualized. T.V. not seen	M. and T. valvulotomy 1954. Not improved. Died Feb. 15, 1958
13 717081 ^{*21:22}	29	F	7.7 mm. Hg diastolic gradient across T.V. No T.I. Moderately severe M.S. T.V. area calculated 1.3 cm. ²	S.V.C. dilated. Moderate enlargement of heart involving R.A., R.V., L.A. R.C.M. 65 mm.	None	M. valvulotomy Nov. 15, 1955, at operation also had mild T.S. and M.I. Doing well at last follow-up, 1958
14 82754 [*]	51	F	Mild T.S. with severe T.I.	Very large heart with all chambers dilated. Double densities on right demonstrating both R.A. and L.A. enlargement. R.C.M. 80 mm.	None	M. valvulotomy 1955, doing well to present
15 635688 ^{*21:22}	33	F	Mild T.S. moderate T.I. Severe M.S. and probably A.S. and A.I. 5 mm. Hg diastolic gradient at rest. Calculated T.V. area 0.9 cm. ²	Large heart with all chambers enlarged. Large R.A. Difficult to evaluate R.C.M. because of dorsal scoliosis	None	Poor condition precluded operation. Died Aug. 24, 1955. At autopsy T.S., T.I., M.S., M.I., A.S., and A.I. with bicuspid aortic valve. All chambers dilated and hypertrophied
16 665215 ^{*21:22}	33	F	6.6 mm. Hg diastolic gradient across T.V. T.I. more severe than T.S. Severe M.S., huge R.A. Calculated T.V. area 1.2 cm. ²	Heart markedly enlarged. Large R.A.	None	No surgery. Lost to follow-up
17 645020 ^{*21:22}	52	F	8 mm. Hg diastolic gradient across T.V. on exercise. Also mild T.I. Moderate M.S. and M.I. Calculated T.V. area 1.4 cm. ²	Large heart with all chambers involved. Very large R.A. and L.A. R.C.M. 80 mm.	Huge R.A. measuring 115 mm. A "jet" in R.A. indicated T.I. R.V. moderately enlarged. L.A. 4 times enlarged. L.V. slightly enlarged	Admitted only for catheterization. Thereafter lost to follow-up
18 686668 ^{*21:22}	23	F	Moderate T.S. Valve area 1.7 cm. ² . Moderate A.S. and A.I. 6.8 mm. Hg diastolic gradient across T.V. on exercise	Slight prominence of S.V.C., moderate enlargement of R.A. and L.V. R.C.M. 60 mm.	None	No surgery. Unimproved on last visit in 1958
19 228588 ^{*21:22}	44	F	9 mm. Hg diastolic pressure gradient across T.V. T.I. more severe than T.S. Also moderate M.S. and M.I. Calculated valve area 0.9 cm. ²	Moderate enlargement of all chambers. Mild S.V.C. enlargement. R.C.M. 70 mm.	Enlargement of S.V.C. and R.A. Moderate enlargement of R.V. and L.A.	No surgery. Poor general condition on last admission in 1958
20 610828 ^{*21}	38	F	5.3 mm. Hg pressure gradient across T.V. Moderate T.S. and T.I. Moderately severe M.S.	Moderate enlargement of heart chiefly R.A., R.V. and L.A. R.C.M. 70 mm.	None	M. valvulotomy. Moderate T.S. at operation. Died 2 days postoperatively on Oct. 4, 1956. No autopsy obtained

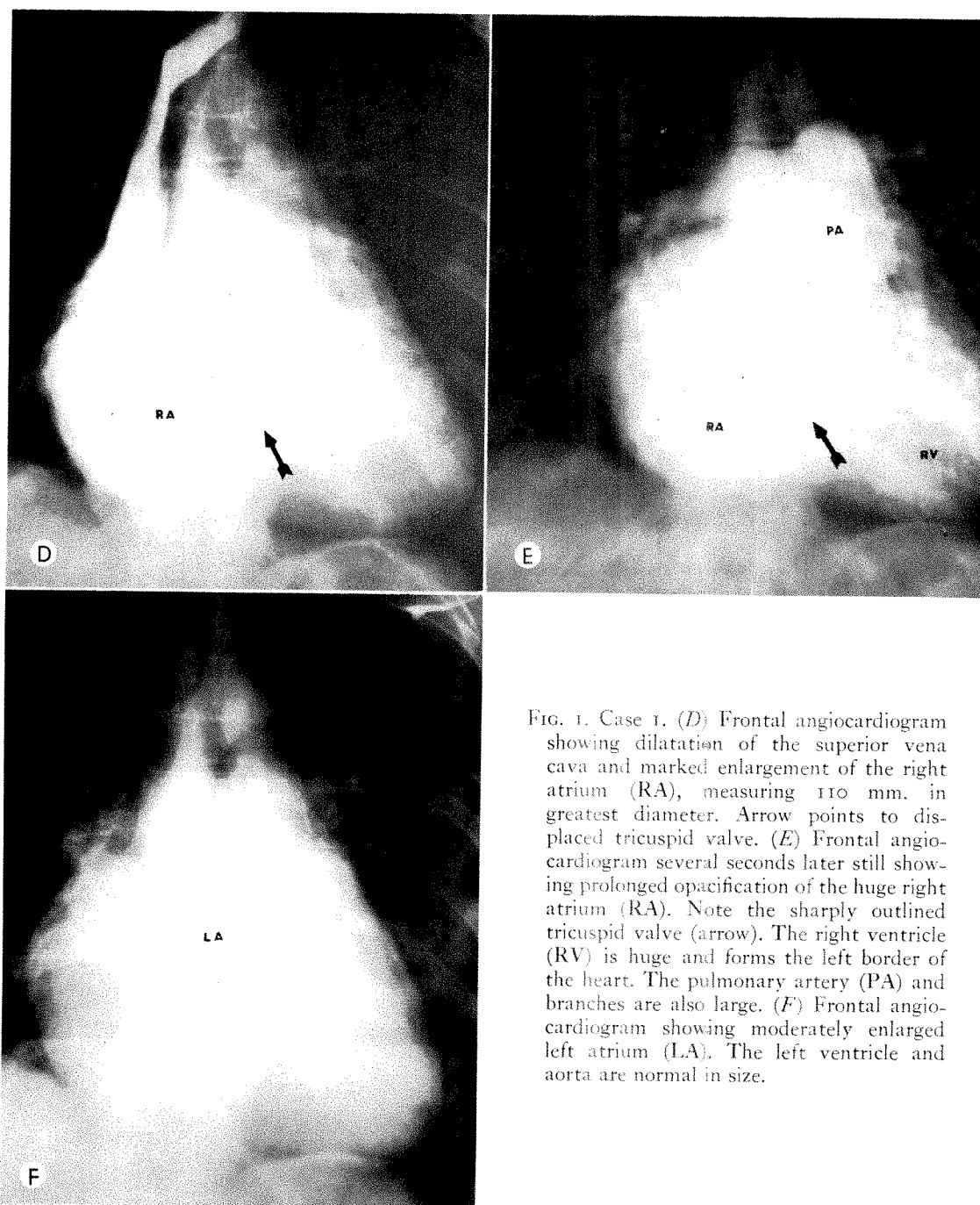


FIG. 1. Case 1. (D) Frontal angiocardigram showing dilatation of the superior vena cava and marked enlargement of the right atrium (RA), measuring 110 mm. in greatest diameter. Arrow points to displaced tricuspid valve. (E) Frontal angiocardigram several seconds later still showing prolonged opacification of the huge right atrium (RA). Note the sharply outlined tricuspid valve (arrow). The right ventricle (RV) is huge and forms the left border of the heart. The pulmonary artery (PA) and branches are also large. (F) Frontal angiocardigram showing moderately enlarged left atrium (LA). The left ventricle and aorta are normal in size.

sis. In contrast, in this series of tricuspid stenosis, the variation was from $+2.19$ mm. to $+19.2$ mm. Hg (diastolic gradient) across the tricuspid valve. Furthermore, the elevated gradient across the tricuspid valve also increased during exercise. From the hemodynamic data the calculated area of

the stenosed tricuspid valve varied from 0.6 to 1.3 cm.², and this was usually verified at operation and at autopsy.

The ages of the patients at the time of initial study ranged from twenty-three to fifty-two years. Seventeen of the 20 patients were female, and this is in accord with the

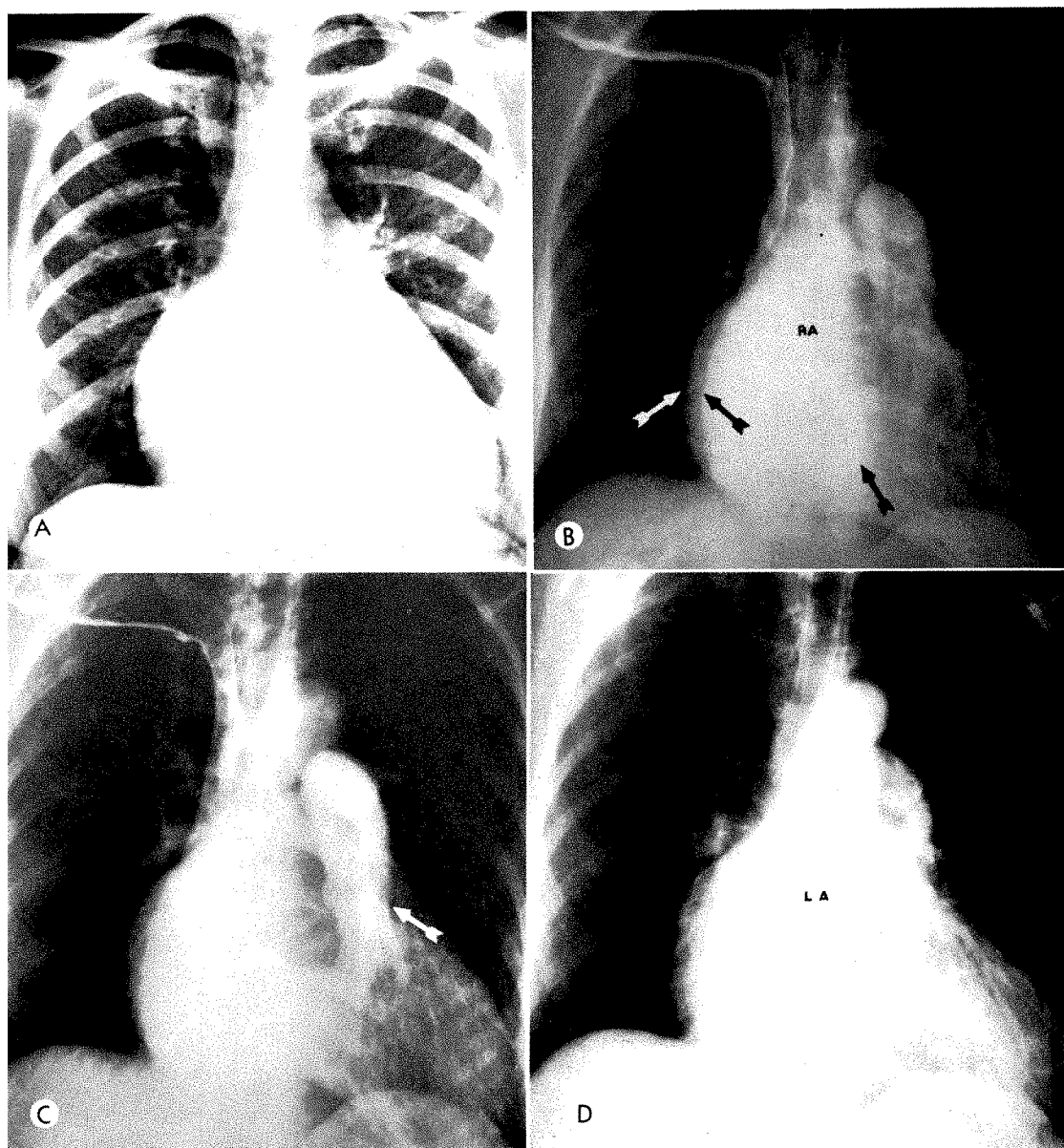


FIG. 2. Case 2. *Quadrivalvular rheumatic valvulitis (verified by autopsy)*: (A) Frontal teleroentgenogram showing generalized cardiac enlargement with marked prominence of the right atrium. (B) Frontal angiogram showing a small pericardial effusion (upper arrows). The large right atrium (RA) measuring 80 mm. in diameter and the displaced thin, lucent tricuspid valve (lower arrow) are evident because of the poorly opacified right ventricle. (C) Later in the series, the right atrium is still opacified and pulmonic valvular stenosis (arrow) is clearly demonstrated. (D) Serial frontal angiogram illustrating a moderately enlarged left atrium (LA). Only faint visualization of the left ventricle occurred owing to slight mitral stenosis.

higher incidence of rheumatic heart disease in women. Generalized cardiac chamber enlargement was found on the conventional roentgenograms of all the 19 proved rheumatic tricuspid stenosis patients. In these, at least 1 other valve was involved.

Case 2 (Fig. 2, A-D) was unique in that all 4 valves were involved.^{5a} Case 5 (Fig. 5, A and B) was also unusual because only isolated tricuspid stenosis was present due to either a congenital malformation or rheumatic valvulitis.

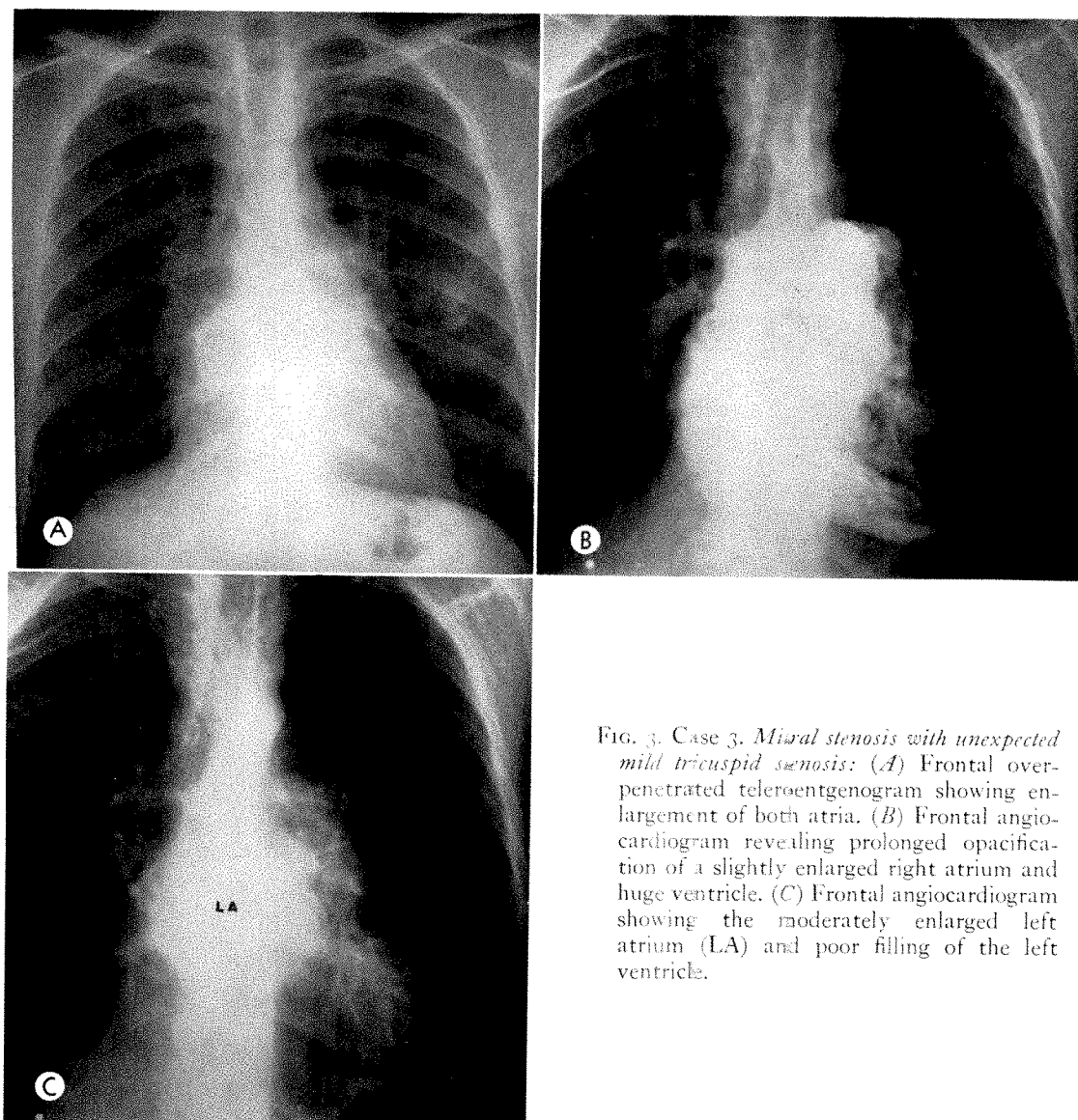


FIG. 3. Case 3. *Mitral stenosis with unexpected mild tricuspid stenosis*: (A) Frontal overpenetrated teleroentgenogram showing enlargement of both atria. (B) Frontal angiogram revealing prolonged opacification of a slightly enlarged right atrium and huge ventricle. (C) Frontal angiogram showing the moderately enlarged left atrium (LA) and poor filling of the left ventricle.

Owing to right atrial enlargement, the cardiac configuration on the conventional teleroentgenogram in frontal views in many of the cases of tricuspid stenosis (Fig. 1A; 2A; and 6A) was globular in shape and approximated the appearance of a moderate to large pericardial effusion. Right atrial measurements were made according to the schema devised by Goodwin *et al.*¹⁹ They estimated right atrial enlargement in 21 cases of rheumatic tricuspid stenosis by measuring from the right border of the heart to the midline of the spine on the frontal teleroentgenogram of the

chest and classified atrial enlargement as follows: when the right cardiac measurement was 50 mm., the right atrium was slightly enlarged; from 50 to 71 mm., it was moderately enlarged; from 71 to 90 mm., it was huge; and beyond 90 mm., it was labelled aneurysmal. Similarly, on the conventional frontal teleroentgenogram, the right cardiac measurement to the midline of the thorax in the 20 cases in this series varied from 60 to 120 mm., with an average of 74 mm. Utilizing Goodwin and co-workers' rule: 12 cases in our series were classified as having right atria of moderate

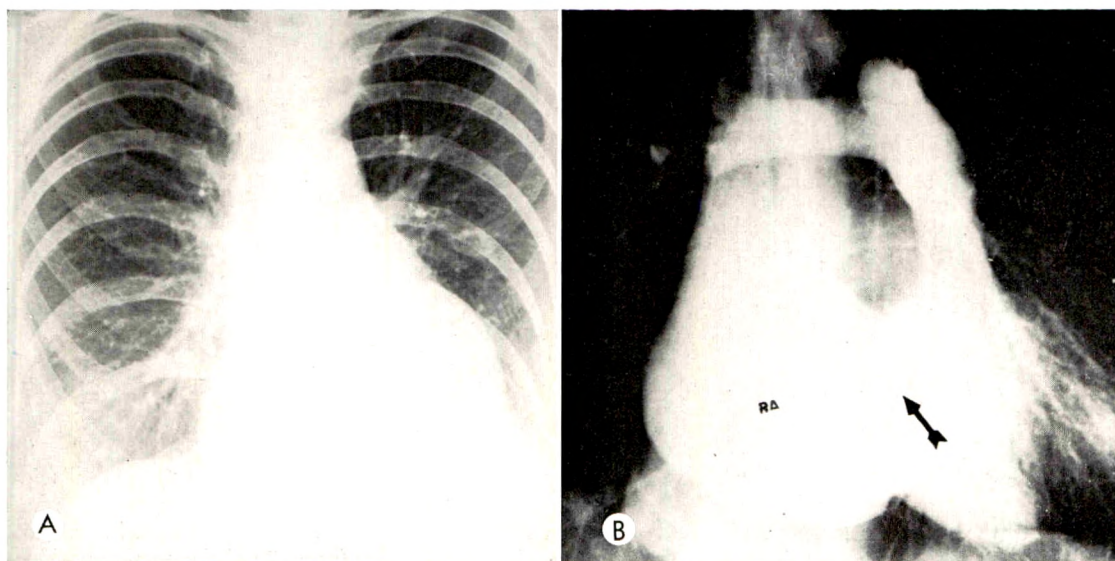


FIG. 4. Case 4. *Scoliosis of the spine altering the right heart border in a patient with tricuspid and mitral stenosis:* (A) Frontal teleroentgenogram showing scoliosis of the spine to the right obscuring the right atrium. (B) Frontal angiogram showing the huge right atrium (RA) measuring 120 mm. in greatest diameter and a fine thin, lucent tricuspid valve (arrow) displaced to the left. The right ventricle is also markedly enlarged.

size, in 6 considerably enlarged, and in 1 (Case 12) it was of aneurysmal proportion. That the prominent right border of the heart in the frontal view represented an enlarged right atrium and not a greatly enlarged left atrium due to advanced mitral disease could frequently be ascertained by an overpenetrated frontal teleroentgenogram. This also readily demonstrated the size and position of the left atrium (Fig. 3A; and 6A). In one instance (Case 4), the right atrium was not prominent, although enlarged, owing to scoliosis of the spine (Fig. 4A). Widening of the superior mediastinum to the right on the frontal roentgenograms of the chest owing to dilatation of the superior vena cava was evident in almost every case (Fig. 1A; 2A; 5A; and 6A). In Case 10 only, there was considerable deviation of the esophagus to the left by a greatly enlarged right atrium.²⁴

Enlargement of the right atrium and widening of the superior vena cava (Fig. 1, D and E; 2, B and C; 3B; 4B; and 5B) were clearly demonstrated in the 9 patients who were studied angiographically. The largest right atrium, visualized angiographically (Case 12), was gigantic

and measured 130 mm. in greatest diameter. In every instance, reflecting the degree of tricuspid stenosis, there was moderate to marked delay in emptying of the right atrium with corresponding poor opacification of the right ventricle. In almost every case the tricuspid valve was visualized as a thin, almost vertical, lucent line beginning at the atrioventricular groove. The valve was always shifted well to the left of the spine (Fig. 1E; 2B; 4B; and 5B).^{5b,31b} Enlargement of the left atrium and other chambers (Fig. 1F; 2, C and D; 3, B and C; and 4B) was evident in the patients with multivalvular disease. The pulmonary valve was stenotic in Case 2 (Fig. 2C) only, and at autopsy it was found to be associated with slight infundibular narrowing. A small pericardial effusion, probably due to heart failure, was also demonstrated in Case 2 (Fig. 2B). In Case 17, there was a "jet"^{13,33} in the right atrium, indicating tricuspid insufficiency and this diagnosis was also confirmed by cardiac catheterization.

DISCUSSION

Tricuspid stenosis may be a congenital or acquired malformation. Isolated (congeni-

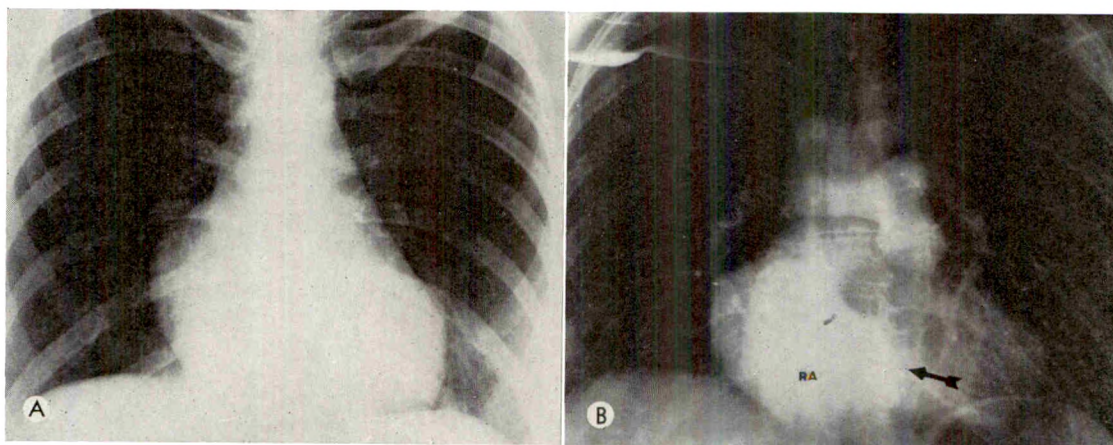


FIG. 5. Case 5. *Isolated (congenital) tricuspid stenosis markedly improved by valvulotomy:* (A) Frontal teleroentgenogram showing marked prominence of the right atrium. (B) Frontal angiocardigram showing that all of the cardiac enlargement is due to the right atrium (RA) which measured 80 mm. in greatest diameter. Again note the fine, thin and laterally displaced tricuspid valve (arrow) and the poorly opacified right ventricle.

tal or acquired) tricuspid stenosis is very rare.^{16,23} Acquired tricuspid stenosis is usually associated with other valvular lesions and is almost always related to rheumatic valvulitis. Rarely, tricuspid stenosis results from bacterial endocarditis with vegetations. Another cause of obstruction or narrowing of the tricuspid valve is right atrial thrombus or tumor, especially myx-

oma.^{1,4,6,20,26,38} Rarely, tricuspid stenosis occurs in association with systemic lupus erythematosus,¹⁸ carcinoid,²⁷ endocardial fibroelastosis,¹¹ and endomyocardial fibrosis.¹⁰

In this series, 19 patients with tricuspid stenosis had rheumatic heart disease with multivalvular involvement. Case 5, however, had isolated tricuspid stenosis and

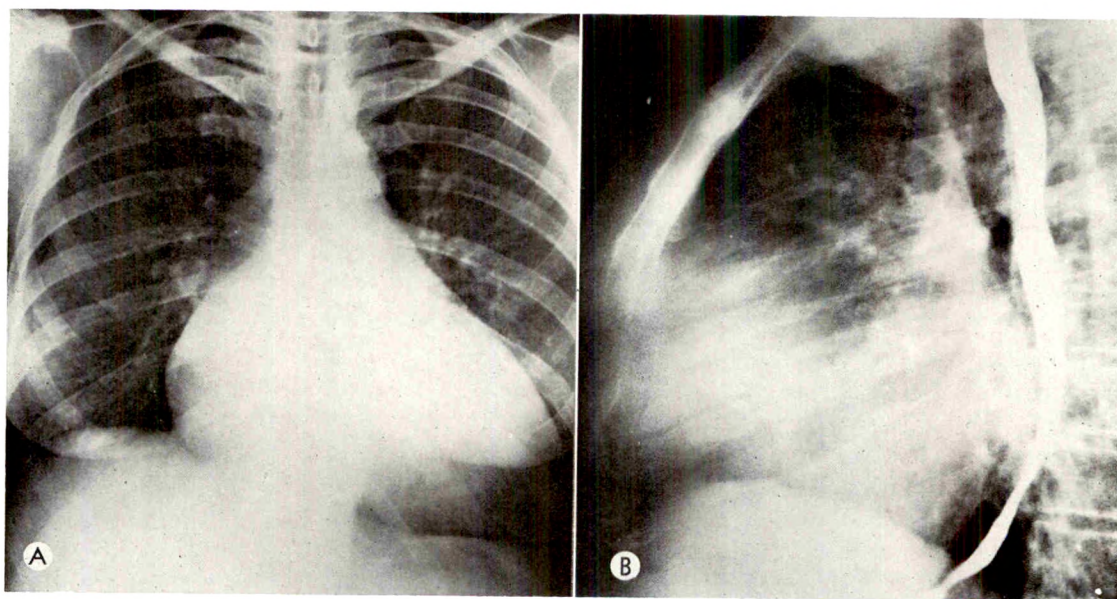


FIG. 6. Case 6. *Multivalvular (tricuspid, mitral, and aortic) rheumatic stenosis:* (A) Frontal teleroentgenogram showing a huge heart with enlarged double contours of enlarged atria (confirmed by angiocardigraphy). (B) Left lateral teleroentgenogram revealing posterior deviation of the esophagus by the enlarged atria. The enlarged right cardiac chambers fill the retrosternal space.

since biopsy of the right atrial appendage at the time of valvulotomy showed no Aschoff bodies, the thesis that the tricuspid stenosis was probably of congenital origin seems likely.

The clinical diagnosis of tricuspid stenosis will often be overlooked unless the physician's index of suspicion is high. Anasarca, prominent venous pulsation in the neck, enlargement of the liver, easy fatigability, icterocyanosis (a combination of cyanosis and jaundice) but with only mild dyspnea in a patient with rheumatic heart disease, are the classic signs and symptoms. In recent times, a characteristic diastolic murmur with a thrill in the third, fourth and fifth intercostal spaces to the left of the sternum has become recognized as good evidence for the diagnosis of tricuspid stenosis. The changes in intensity of the murmur, the murmur becoming louder during inspiration and softer in expiration, are additional aids in identifying the lesion and differentiating it from mitral stenosis.^{21,20,31}

The definitive diagnosis of tricuspid stenosis can only be made after careful cardiac catheterization by which a diastolic atrioventricular pressure gradient is demonstrated. Since these pressure gradients may be low, they can be missed unless the catheter team is alert and searches for tricuspid stenosis in every patient with rheumatic heart disease. Only by this method can stenosis and insufficiency of the tricuspid valve be properly evaluated and differentiated.

In this series of 20 cases of tricuspid stenosis, 12 patients had cardiac surgery. Four patients (Cases 1, 5, 9 and 12) had tricuspid valvulotomy. Case 1 had both mitral and tricuspid valvulotomies and did well postoperatively. Case 5 had tricuspid valvulotomy only and had an excellent result. Case 9 recently had simultaneous aortic, mitral and tricuspid valvulotomies and was markedly improved although the follow-up period is still short. Case 2 had mitral and tricuspid valvulotomies in 1954, but did poorly and died; no autopsy was obtained. Of the entire series, 5 pa-

tients (Cases 2, 10, 12, 15 and 20) have died. Autopsies were obtained in 3 instances (Cases 2, 10 and 15) and confirmed the catheterization and roentgenographic diagnoses (Table 1).

The initial contribution of the radiologist in diagnosis of tricuspid stenosis may be small, since manifestations of mild to moderate right atrial enlargement are at best subtle on conventional roentgenograms. And even if there clearly appears to be right atrial enlargement, the reason for this will remain uncertain until cardiac hemodynamic data are secured to differentiate between tricuspid stenosis and insufficiency. The radiologist, however, may be able to detect the large right atrium in the patient with rheumatic heart disease and initiate further roentgenographic and hemodynamic studies. The best view of the heart for recognition of right atrial enlargement is the frontal film, since frequently the right border of the heart has a rounded bulge due in part to dilatation of the right auricular appendage. Widening of the right superior mediastinum owing to dilatation of the superior vena cava is also common. In this series there was excellent correlation between the right cardiac measurement and right atrial size (Table 1). Accordingly, the Goodwin *et al.*¹⁹ measurements for estimation of right atrial enlargement are recommended. Identification of the left atrium on the overpenetrated frontal roentgenogram also permitted indirect determination of the size and position of the right atrium (Fig. 3A; and 6A). Dilatation of the right auricular appendage in some cases is most conspicuous in the left anterior projection (Fig. 1B). Localized posterior displacement of the barium filled esophagus just above the diaphragm by a large right atrium on the right anterior oblique roentgenogram was infrequently seen. Filling of the retrosternal space by an enlarged right atrium, or ventricle, is commonly seen (Fig. 6B), and is a valuable sign of right heart enlargement. However, specific cardiac chamber enlargement on conventional roentgenograms may be difficult to recognize, especially when there is

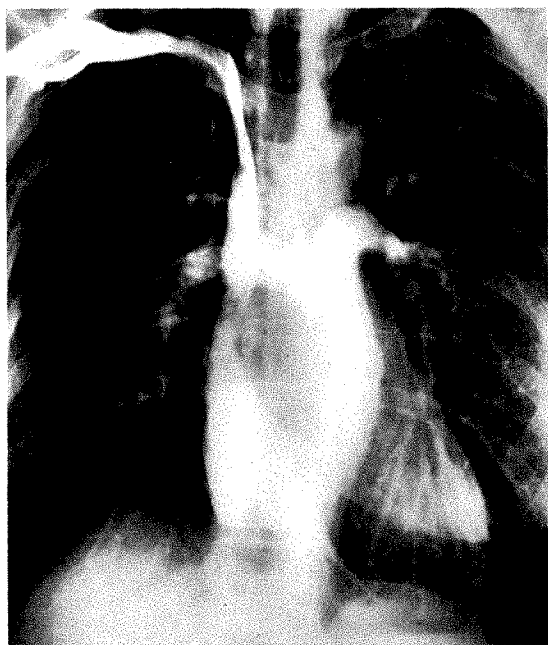


FIG. 7. *Frontal angiogram in a 40 year old woman with mitral and aortic stenosis:* The right atrium and right ventricle are normal in size. Note that the tricuspid valve is situated over the mid-spine and that equal opacification of the chambers prevents clear-cut visualization of the tricuspid valve.

multivalvular disease. Calcification of the tricuspid valve in contradistinction to the mitral and aortic valves is apparently very rare^{7a} and was not identified in this series.

Significant information was obtained by angiocardiology. Prolonged opacification of a large right atrium caused by the stenotic tricuspid valve was seen in every instance. As a result, the filling time of the right ventricle was also prolonged. In almost every case the tricuspid valve was clearly identified and always lay well to the left of the midline, shifted by the large right atrium.^{5b,31b} Indeed in only 1 instance (Case 3, Fig. 3B) in which there was only a mild degree of tricuspid stenosis (5 mm. Hg gradient), the tricuspid valve was poorly visualized. In contrast, a normal position of the tricuspid valve was demonstrated in a case of rheumatic heart disease without tricuspid valve involvement (Fig. 7). By intravenous angiocardiology, however, the definitive diagnosis

of tricuspid stenosis cannot be made because it is not possible to differentiate with certainty between tricuspid stenosis and insufficiency. For this, selective angiocardiology and cine-angiocardiology have been advocated.^{2,8} It is doubtful, though, that these techniques will provide the high degree of accuracy achieved by simultaneous cardiac catheterization of the right atrium and ventricle. In addition, angiocardiology is frequently very helpful in the anatomic delineation of other valvular lesions in rheumatic heart disease.¹²

Angiocardiology also definitively establishes the diagnosis of right atrial myxoma (Fig. 8, A-D). Right atrial enlargement and prominence of the superior vena cava may be seen on the conventional frontal roentgenogram (Fig. 8A). By angiocardiology an irregular filling defect caused by a tumor measuring 7.5 by 6 cm. which had prolapsed through the tricuspid valve during systole of the atrium (Fig. 8, B to D) was clearly outlined. The myxoma had produced isolated tricuspid stenosis and right heart failure.⁶

The roentgen differential diagnosis of tricuspid stenosis includes lesions which cause enlargement or distortion of the right atrium, such as: functional or anatomic tricuspid insufficiency, tricuspid atresia, pulmonary stenosis, Ebstein's tricuspid anomaly, pericardial effusion, pericardial cyst or tumor, mediastinal tumor, and intra-atrial tumors or thrombi.^{15,32,35,36,38} The differentiation of the above lesions may be very difficult even though the history is known and physical examination and conventional chest roentgenography have been performed. Rarely, myxomas calcify and then create an unusual roentgenoscopic and roentgenographic picture.^{7b} Cardiac catheterization, dye dilution tests and angiocardiology are of definite value in establishing the diagnosis of the congenital cardiovascular anomalies. Angiocardiology, especially, provides valuable differential diagnostic data by excluding pericardial effusions, pericardial tumors and mediastinal masses adjacent to the right atrial border.^{35,36}

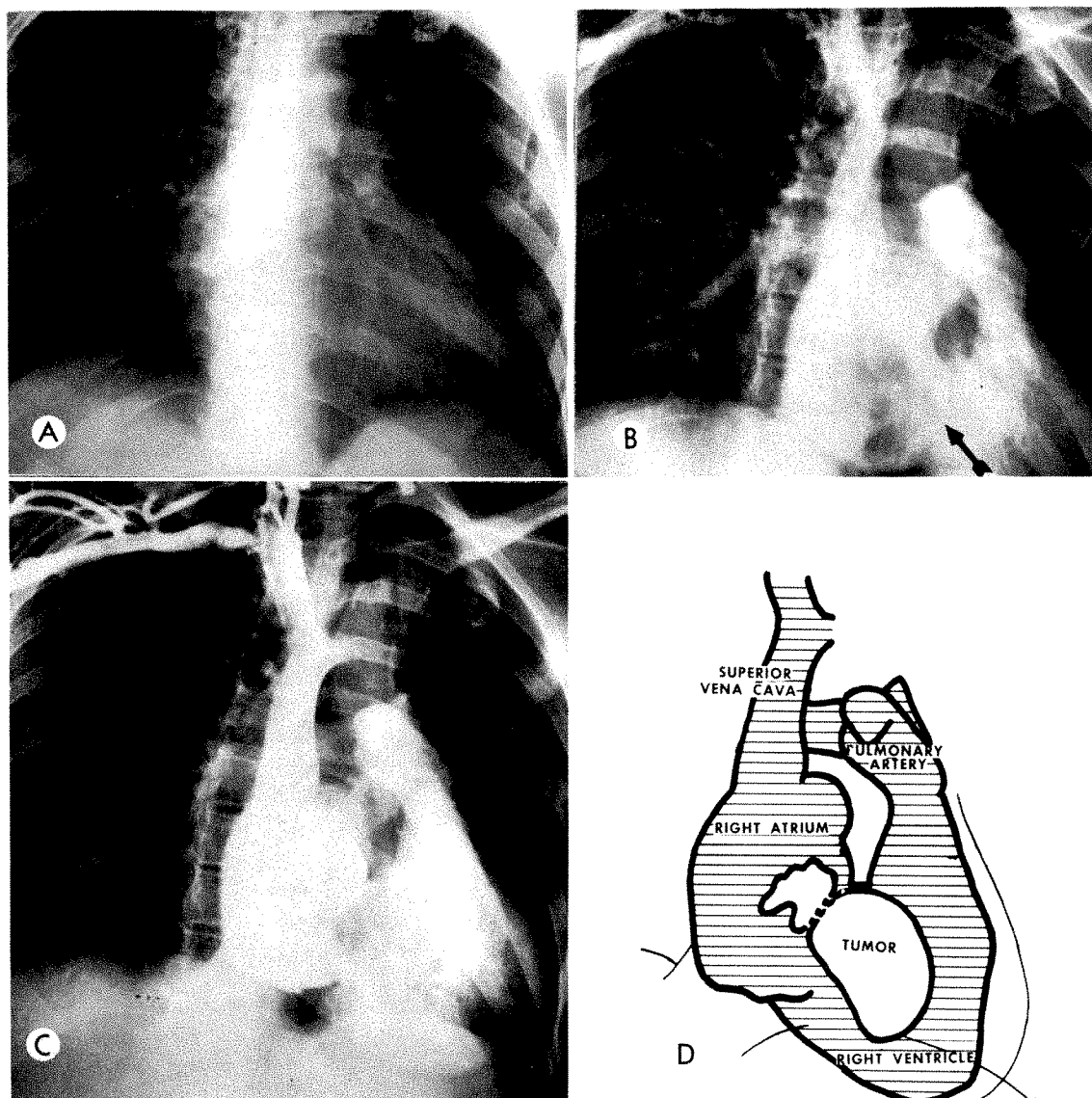


FIG. 8. *Tricuspid stenosis due to right atrial myxoma*: (A) Conventional frontal roentgenogram showing right atrial enlargement. (B) Angiocardiogram showing a filling defect in the outflow tract of the right atrium caused by a myxoma. Note the adjacent translucent and displaced tricuspid valve (arrow). (C) Later in the series, the myxoma had prolapsed through the tricuspid valve into the inflow tract of the ventricle. (D) Tracing of C. (Published by permission of Dr. Martin S. Belle.⁶)

SUMMARY AND CONCLUSION

The *in vivo* diagnosis of tricuspid stenosis is important since this lesion is usually amenable to surgical alleviation. Tricuspid stenosis is not an uncommon condition; in a large series of patients with rheumatic heart disease coming to necropsy, 5 to 14 per cent have had moderate to severe tricuspid stenosis.

By cardiac catheterization a definitive

diagnosis of tricuspid stenosis can be established. Furthermore, differentiation of tricuspid stenosis from tricuspid insufficiency is possible. Careful clinical examination, with special attention to the characteristic behavior of the diastolic murmur on respiration coupled with its location in the third, fourth, and fifth intercostal spaces to the left of the sternum, can indicate the diagnosis.

The radiologist by noting an enlarged right atrium on the roentgenogram of a patient with rheumatic heart disease is also in a position to suspect that tricuspid disease is present, although it usually is impossible to differentiate between tricuspid stenosis and insufficiency on conventional roentgenograms. The most reliable sign of right atrial enlargement is a prominent right atrial bulge visualized on the frontal conventional roentgenogram, especially when it is overpenetrated. Dilatation of the right auricular appendage is sometimes best appreciated in the left anterior projection. Further data regarding right atrial enlargement can be secured by measuring the right atrial border to the right of the midline of the spine according to the recommendation of Goodwin and his colleagues. Another sign is the visualization of a dilated superior vena cava.

Angiocardiography reveals prolonged opacification of a large right atrium and clear visualization of a markedly displaced tricuspid valve is obtained. The valve can be readily identified as a thin, lucent, vertical line separating the densely opacified right atrium from the less dense right ventricle. Of course, visualization of the cardiac chambers and great blood vessels is also achieved; thereby, multivalvular lesions are demonstrated and the specific diagnosis of valvular disease is established. Right atrial tumors and thrombi are also readily revealed as filling defects in the atria or ventricles. Finally, angiocardiography plays a significant role in differential diagnosis by excluding pericardial effusion, pericardial cysts and tumors, adjacent right cardiac mediastinal masses, and other congenital cardiac anomalies; all of which may simulate a large right atrium.

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ADDENDUM

Since this paper was submitted for publication, GIALLORETO, O., AÉRICHIDÉ, N., and ALLARD, P. P. have reported 3 patients

with rheumatic tricuspid valvular stenosis who also had stenotic involvement of the other valves (*Am. J. Cardiol.*, 1961, 7, 865-873).

Thanks are due to Dr. Daniel S. Lukas for providing the cardiac catheterization data, to Dr. Laurence Miscall for referring and furnishing the follow-up findings of Cases 5 and 7, and to Dr. Martin S. Belle for permission to reproduce Figure 8, A-D.

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THE AMERICAN JOURNAL OF ROENTGENOLOGY, RADIUM THERAPY AND NUCLEAR MEDICINE

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* *Ex officio.*

EDITORIALS

CONTRAST LARYNGOGRAPHY IN THE DIAGNOSIS OF LARYNGEAL NEOPLASMS

THE observation of persistent pooling of opaque media in the laryngopharynx during the type of bronchographic studies pioneered by Jackson in 1936 led to the development of deliberate contrast laryngography. The introduction of a suitable contrast substance and an appreciation of the benefits to be derived from proper anesthesia have considerably expanded within the last 5 years the previously limited use of this examination.

Early, in laryngeal evaluation of neoplasms, small occlusal films were placed in the hypopharynx. Other techniques made use of low kilovoltage with short target skin distances. These methods of frontal roentgenography were restricted in scope and lacked detail. Kovacs¹ in 1960 proposed asymmetric oblique laryngeal projections to allow a more precise definition of tumors arising in such structures as the false cord and laryngeal ventricle which do not lend themselves well to examination in the sagittal and coronal planes.

The accepted method in the study of laryngeal neoplasms remains the high contrast lateral roentgenography of the cervical region complemented by frontal laminagraphic sections through the laryngeal soft tissues. Leborgne,² who first suggested the use of laminagraphy, has stated that the axis of the organ examined should be parallel to the plane of projection to prevent significant distortion, thus precluding the identification of a nonexistent tumor. Careful selection of the central axis and long target film distances are required to

lessen distortion and magnification.³ Some detail is lost due to the motion of the tube and film, as explained by Kovacs, with resulting soft tissue air contrast sometimes insufficient to detect minimal pathologic alteration. The clinical advantages of this type of examination have been admirably documented by Fletcher and his co-workers.³

In serial descriptions Powers *et al.*,^{4,5} in 1957 and 1961, have detailed their experience with another method, in which the laryngeal structures are coated with opaque material, and they have shown the reliability of contrast laryngograms so produced in the diagnosis of laryngeal tumors. They emphasize the importance of carefully conducted topical anesthesia for the success of such a procedure; they use atropine and barbiturate premedication followed by dropping the topical anesthetic over the back of the tongue and spraying the larynx and pharynx. This permits the retention of moderate amounts of opaque substance and allows a more uniform coating of the mucosal surfaces by reducing the stimulation to cough and swallow. Through a curved cannula, 5 to 10 cc. of opaque material is then instilled into the laryngopharynx during quiet inspiration, ensuring complete covering of the valleculae, pyriform sinuses and the larynx. Dionosil is the medium of choice because of its uniform

¹ KOVACS, A. Asymmetric roentgenography of the vocal cords. *Acta radiol.*, 1960, 53, 426-432.

² LEBORGNE, F. Tomographic study of cancer of the larynx. *AM. J. ROENTGENOL. & RAD. THERAPY*, 1940, 43, 493-499.

³ FLETCHER, G. H., OLD, J. W., and LOQUVAM, G. S. Topographic approach to roentgenologic and pathologic examination of laryngopharyngeal tumors. *Radiology*, 1954, 63, 361-380.

⁴ POWERS, W. E., MCGEE, H. H., JR., and SHAMAN, W. B. Contrast examination of the larynx and pharynx. *Radiology*, 1957, 68, 169-178.

⁵ POWERS, W. E., HOLTZ, S., OGURA, J., ELLIS, B. L., and MCGAVRAN, M. H. Contrast examination of the larynx and pharynx, accuracy and value in diagnosis. *AM. J. ROENTGENOL., RAD. THERAPY & NUCLEAR MED.*, 1961, 86, 651-660.

spread and maximum contrast capability. Spot roentgenograms are obtained in the frontal and lateral planes employing high kilovoltage, rapid exposure techniques. Film pairs, exposed during several maneuvers comprising the study, provide valuable clues in the detection of disease. During quiet nasal inspiration, the hypopharynx is at rest and the larynx is fully opened. With phonation the cords are approximated, the laryngeal position is normally altered, the ventricles are completely opacified and the anterior commissure is better demonstrated. The modified Valsalva maneuver aids in outlining the well distended pyriform sinuses. In the true Valsalva maneuver, these are obliterated by movement of the epiglottis and the arytenoids and the contrast medium is forced along the mucosal surfaces of the subglottic space with its contours accentuated. Appraisal of the anterior commissure and the posterioicoid region is limited, otherwise the entire laryngopharynx is visualized in all projections. Laryngeal topography is demonstrated and physiologic, or possibly pathologic, dynamics of the laryngopharyngeal apparatus are assessed. Clear delineation of anatomic detail is realized, and with experience minor variations are easily recognized.⁴

During a 3 year period Powers *et al.* have employed contrast laryngography in the diagnosis of 99 malignant laryngeal neoplasms, precisely determining the site of origin of the tumor, the area of involvement, the size of the tumor, the status of the surrounding structures, the mobility of the cords and the circumferential extent of the tumor in 92 per cent of the cases.

The tumors were classified as supraglottic, glottic and infraglottic as proposed previously, with the addition of the transglottic type. The classification separates the lesions with respect to the two major lymphatic pathways. Most of the errors were made in studying the infraglottic lesions. Four of 9 cases were incorrectly described as transglottic because the mass compressed and obliterated the ventricle and produced enlargement of the cord.

With the exception of tumors within the anterior commissure, those crossing the midline were completely outlined. The inferior margins of bulky vestibular and false cord tumors were well shown and the true status of the cord envisaged. The size of the tumor was determined to within 3 to 6 mm., depending on the site of origin. Adequate margins of safety were correctly predicted in supraglottic neoplasms prior to confirmation following only partial laryngectomy. In 6 of 12 additional patients undergoing total laryngectomy, limited involvement permitting more conservative procedures was conclusively revealed by preoperative contrast laryngography.

Adhering to the principles of Powers *et al.*, Medina, Seaman, Carbajal and Baker⁶ have performed more than 100 contrast laryngographies with practically no technical failures. Fabrikant, Richards, Tucker and Dickson⁷ have recently added television image intensification fluoroscopy and cinefluorography to contrast laryngography which they feel enhance the value of the method, despite some loss of detail in these examinations. In 13 cases described by this group, laryngography proved a valuable adjunct in the diagnosis of laryngeal cancer.

Molnar and Prior,⁸ at the Sixty-second Annual Meeting of the American Roentgen Ray Society, reported a new method of effecting topical anesthesia for bronchographic studies by an intermittent positive pressure apparatus. A topical anesthetic is nebulized and the mist, suspended in 100 per cent oxygen, is inhaled under 5 cm. water pressure. Because of small particle size and the abundance of oxygen, the nebulized solution can be inhaled very comfortably. Only 12 minutes of continuous breathing is required to achieve adequate,

⁶ MEDINA, J., SEAMAN, W. B., CARBAJAL, P., and BAKER, D. C. Value of laryngography in vocal cord tumors. *Radiology*, 1961, 77, 531-542.

⁷ FABRIKANT, J. L., RICHARDS, G. J., JR., TUCKER, G. F., JR., and DICKSON, R. J., Contrast laryngography in the evaluation of laryngeal neoplasms. *AM. J. ROENTGENOL., RAD. THERAPY & NUCLEAR MED.*, 1962, 87, 822-835.

⁸ MOLNAR, W., and PRIOR, J. A. Anesthesia for bronchography utilizing intermittent positive pressure breathing apparatus. *AM. J. ROENTGENOL., RAD. THERAPY & NUCLEAR MED.*, 1962, 87, 836-839.

uniform upper respiratory tract anesthesia. This technique might be adaptable to contrast laryngography resulting in further simplification of the method with retention of, or increase in, definitive quality.

The meticulous accumulation of clinical data with concise pathologic correlation has offered considerable insight into the biologic behavior of laryngeal neoplasms in terms of site of origin, size of the lesion and histologic differentiation. In particular, this has permitted a more rational prognostication of lymph node involvement. Radiotherapeutic techniques have been congruently altered. Conservative changes

have been made in the surgery of the larynx, permitting partial laryngopharyngectomy and preservation of the cord and some of its supporting structures, only if the tumor is adequately localized during the diagnostic work-up.

The direct, simple method of contrast laryngography is of definite value in the management of laryngeal neoplasms, and it may assist in a more complete exploitation of newer oncologic and therapeutic concepts.

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WILLIAM H. GIBBON, M.D.

1899-1961

DR. WILLIAM H. GIBBON died suddenly December 4, 1961, after a short illness. He spent almost his entire medical career in the practice of radiology. Dr. Gibbon was born October 15, 1899, at Norwood, Missouri. He served in the U. S. Army during the first World War. After his

war service he attended the University of Nebraska College of Medicine, graduating in 1925. Following his internship at Clarkson Memorial Hospital in Omaha, Nebraska, he practiced general medicine for a short while at Harvard, Nebraska.

In 1928, Dr. Gibbon undertook a res-

idency in radiology at the University Hospital at Iowa City, Iowa. He continued there as Associate Professor of Radiology from 1930 to 1934. He came to Sioux City, Iowa, in 1934 where he was attending radiologist at four hospitals and maintained a private office with his associates until the time of his death.

Dr. Gibbon was certified as a Diplomate of the American Board of Radiology in 1940. He was a Fellow of the American College of Radiology, and a member of the American Medical Association and the American Roentgen Ray Society. During his time on the faculty at the University of Iowa, he contributed valuable articles to the literature. He was Past President of the Iowa Radiological Society and served a long tenure as Secretary of the Woodbury

County Medical Society.

He was an avid sportsman with golf his participating sport. In 1939 he won the Willis S. Manges Memorial Golf Trophy of the American Roentgen Ray Society at Cincinnati, Ohio.

Over the years Dr. Gibbon established for himself a feeling of respect and esteem from his colleagues and associates by his untiring efforts and wise counsel. His friendship, professional ability, and integrity will be remembered by all with whom he came in contact. His passing has left a vacancy in the hearts of many, especially those of us who served with him. He is survived by his wife, Lucy; his daughter, Mrs. N. C. Coates, and family; and his son, William B. Gibbon, Ph.D.

W. S. THOMAN, M.D.



NEWS ITEMS

IRA I. KAPLAN LECTURE

The 11th Annual Ira I. Kaplan Lecture will be held on May 10, 1962 at 5:00 P.M. in the main auditorium of the N.Y.U. Medical School. The guest speaker, Dr. Oscar V. Batson of Philadelphia, will discuss the relationship of tumor spread to the venous systems. This lectureship is sponsored by the Radiation Therapy Alumni Association of Bellevue Hospital.

INTERNATIONAL SYMPOSIUM ON RADIOSENSITIVITY

An international symposium on "Radiosensitivity, Basic Research and Clinical Applications" will be conducted at the Faculty of Medicine, Laval University, Quebec City, Canada, on September 4 and 5, 1962.

The subjects discussed will be those derived from the basic research programs in the field of radiobiology and the application of these principles to the problems of radiotherapy. These will be covered in three sessions run consecutively. Ten papers will be presented and each discussed by an invited speaker.

Both English and French will be the languages of the symposium, with simultaneous translation provided.

This meeting will be open to all interested parties. Advance registration (before the 1st of July) would facilitate the program arrangements.

Information pertaining to the scientific sessions, enrollment, hotel reservations, etc. can be obtained from: Dr. Roger Ghys, Secretary of the Radiobiology Symposium, Faculty of Medicine, Laval University, Ste. Foy, Quebec, Canada.

AEC FELLOWSHIPS IN NUCLEAR SCIENCE AND ENGINEERING

Two hundred and twenty promising young science students from 34 states and

the Commonwealth of Puerto Rico were notified that they have been selected to receive special Atomic Energy Commission fellowships for graduate study during 1962-63.

The AEC Special Fellowships in Nuclear Science and Engineering to which they were appointed are designed to aid and encourage outstanding students who are studying for master's or doctor's degrees in nuclear fields. Administered for the Commission by the Oak Ridge Institute of Nuclear Studies, the fellowships are awarded for one year, and may be used for study at one of 57 designated universities in the United States.

The Institute is a nonprofit educational corporation of 38 southern universities and colleges, operating under contract with the Atomic Energy Commission.

INSTITUTE OF EXPERIMENTAL MEDICINE AND SURGERY OF THE UNIVERSITY OF MONTREAL

The research library of the Institute of Experimental Medicine and Surgery of the University of Montreal has suffered extensive losses owing to destruction by fire.

In attempting to rebuild the library, Professor Selye would enlist the assistance of the readers of this JOURNAL and ask them to send him all available reprints of their work, especially those dealing with Endocrinology and Stress.

At the same time he wishes to point out that the permanent mailing list was also destroyed, hence he shall be able to send reprints of the Institute's publications only to those of our readers who write for them.

The mailing address is: Hans Selye, Professor and Director, Institute of Experimental Medicine and Surgery, University of Montreal, P.O. Box 6128, Montreal 26, Canada.

UNITED STATES ATOMIC ENERGY COMMISSION

ANNUAL REPORT TO CONGRESS OF THE ATOMIC ENERGY COMMISSION FOR 1961. Pp. 540 with numerous illustrations and 16 appendices. United States Government Printing Office, Washington, D. C., January, 1962.

The Annual Report of the United States Atomic Energy Commission for 1961 was submitted to Congress on January 30, 1962 as required by the Atomic Energy Act of 1954. The Chairman of the Commission is Dr. Glenn T. Seaborg, Nobel Laureate, former Chancellor of the University of California at Berkeley and Associate Director of the Lawrence Radiation Laboratory.

The Report has four main parts. The first summarizes the growth of the atomic energy industry in the United States and the effort being made by the Commission to stimulate its further growth. To a certain degree, Part One is a summary of the rest of the Report. While progress in the civilian nuclear power program during 1961 was not as great as it was hoped it would be, the rather impressive number of "firsts" achieved in other areas of the atomic energy program during the year are noteworthy.

Part Two summarizes the joint effort of private industry and the Government to achieve competitive nuclear power. Particular attention is invited to the valuable operating experience being gained from the Shippingport, Dresden, and Yankee atomic power plants. The information being obtained shows that good progress is being made toward the goal of making nuclear power economically competitive, under certain conditions, with power generated from conventional fossil fuels.

In Part Three, which is a general summary of the Commission's activities in other areas, the "Education and Training" section describes such Commission activities as faculty education, equipment

grants, nuclear materials services, and the use of Government-owned facilities for educational purposes. The "International Activities" section of Part Three includes descriptions of activities being carried on to aid in the training of foreign students. Also of interest in Part Three is the summary of the Commission's Plowshare Program under which last December the first nuclear detonation for purely peaceful purposes was conducted. The work being done to recover useful radioisotopes from fission product wastes, and the increasing importance of isotopic power sources to our nation's scientific program should also be of interest in Part Three.

Part Four covers the Commission's program for licensing and regulation of nuclear materials and facilities. As will be noted, a constant endeavor is made to relax, where possible, the more stringent regulations and policies in order to facilitate industrial growth while at the same time assuring that the paramount interests of public health and safety are maintained.

The extensive involvement of colleges and universities in the Commission's program of fundamental research will be described in a supplemental report, "Atomic Energy Research—Life and Physical Sciences, Reactor Development, Waste Management—1961," which will be published this spring. In addition to describing the basic research done under Commission sponsorship last year, this report will include a list of the contract study fields of the more than 1,200 colleges and universities cooperating with the Commission in 1961.

Of particular interest to radiologists is the fact that demand for radioisotopes continues to increase as 438,205 curies were shipped from Oak Ridge National Laboratory during 1961; the previous highest annual shipment figure was the 222,703 curies shipped in 1959.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

ROENTGENOLOGY OF THE ABDOMEN. By Juan M. Taveras, M.D., Professor of Radiology, College of Physicians and Surgeons, Columbia University; Associate Attending Radiologist, Presbyterian Hospital, New York; and Ross Golden, M.D., Visiting Professor of Radiology, University of California at Los Angeles; Emeritus Professor of Radiology, College of Physicians and Surgeons, Columbia University. Cloth. Price, \$9.00. Pp. 184, with 151 illustrations. Williams & Wilkins Company, 428 East Preston Street, Baltimore 2, Md., 1961.

This book is a reprinting of Chapter xv from the 3-volume loose-leaf edition of "Golden's Diagnostic Roentgenology." The authors begin with basic considerations of the abdomen anatomically and of the various contrast methods used in diagnostic procedures.

This is followed by an excellent discussion of the intra-abdominal masses and their effects of displacement on the abdominal structures, with descriptions of the changes of the various organs and the barium filled intestine in the erect, decubitus, and recumbent positions. The changes produced by these masses, both intraperitoneal and extraperitoneal, in the anatomic divisions of the abdomen are compartmentalized and particular attention is given to the special diagnostic techniques used for their detection.

Separate sections deal with the solid abdominal organs and their appearances in the normal as well as in various disease states. These include the liver, spleen, pancreas, adrenals and the genital system. Two comprehensive sections on abdominal venography and abdominal calcifications conclude this text. Many fine roentgenographic reproductions and appropriate diagrams are used for illustrations. The printing is of excellent artistic quality.

This splendid book should be a welcome addition to the library of every radiologist.

GEORGE A. KLING, M.D.

RADIOGRAPHIC ATLAS OF SKELETAL DEVELOPMENT OF THE FOOT AND ANKLE; A STANDARD

OF REFERENCE. By Normand L. Hoerr, Ph.D., M.D., (deceased), S. Idell Pyle, Ph.D., and Carl C. Francis, M.D., The Department of Anatomy, Western Reserve University School of Medicine, Cleveland, Ohio. Cloth. Price, \$9.50. Pp. 164, with many illustrations. Charles C Thomas, Publisher, 301-327 East Lawrence Avenue, Springfield, Ill., 1962.

Based on the classic work of T. Wingate Todd and William W. Greulich, the authors have compiled an excellent and well illustrated Atlas, similar in text and format to the well known "Radiographic Atlas of Skeletal Development of the Hand and Wrist."

Through painstaking analysis, they have developed a single standard radiograph instead of the two standards used previously. Thirty plates are presented, illustrating the salient steps in the development of the foot and ankle from infancy through adulthood. Maturity indicators for each individual bone are appropriately described and are more fully illustrated by line drawings in a separate section. Brief sections are also devoted to the regularly occurring accessory bone growth centers and handicaps to optimal development of individual bones.

This atlas will be an invaluable reference tool for those interested in the growth and development of children, particularly the pediatrician, the radiologist, and the orthopedic surgeon.

In the Preface, mention is made that the preparation of this Atlas was interrupted during 1958 by the illness and death of the senior author, Dr. Normand L. Hoerr, who was directing its composition. The Department of Anatomy of Western Reserve University School of Medicine appropriately presents this volume as a tribute to his memory.

DAVID P. CORBETT, M.D.

THE NORMAL SKULL; A ROENTGEN STUDY. By Robert Shapiro, M.D., Chairman, Department of Radiology, Hospital of Saint Raphael, New Haven; Associate Clinical Professor of Radiology, Yale University School of Medi-

cine; and Arnold H. Janzen, M.D., Assistant Radiologist, Hartford Hospital, Hartford; Former Chairman, Department of Radiology, Grace-New Haven Community Hospital and Yale University School of Medicine, New Haven. Cloth. Price, \$18.00. Pp. 257, with 645 illustrations. Paul B. Hoeber, Inc., 49 E. 33rd. St., New York 16, N. Y., 1960.

The purpose of this book is to provide a source of study and reference on the wide range of variability of the normal skull. It presents, in a single volume, a concise, easily readable review of the normal anatomy and its variants.

The authors have drawn considerably from their own experience as well as from current articles and textbooks in the field. Included are chapters on technique, development, and mensuration, as well as separate chapters on such areas as the sella turcica, paranasal sinuses, and the ear and mastoid. All of these are generously supplemented with diagrams and reproductions of roentgenograms of good quality and detail.

This book is designed and recommended particularly for the radiologist and those in the neurologic specialties.

HOWARD J. WEST, M.D.

VERTEBRAL AND CAROTID ANGIOGRAMS IN TENTORIAL HERNIATIONS; INCLUDING ROENTGEN ANATOMY OF THE TENTORIAL INCISURE. By Hans F. Plaut, M.D., Chief, Radiology Service, Veterans Administration Center, Dayton, Ohio; Clinical Assistant Professor of Radiology, Ohio State University, College of Medicine, Columbus, Ohio; and Formerly, Instructor in Radiology, University of Cincinnati College of Medicine, Cincinnati, Ohio. Cloth. Price. \$10.50. Pp. 155, with many illustrations. Charles C Thomas, Publisher, 301-327 East Lawrence Avenue, Springfield, Ill., 1961.

With this excellent work, the author must be considered as one of the most authoritative neuroradiologists in America.

The first part of the book consists of a detailed anatomic study of the tentorial incisure and of its roentgenologic projection. This study is the result of an exhaustive investigation on the part of the author who had to dissect more than 100 skulls to get an exact idea of the normal variations.

Part 2 contains a description of the different tentorial herniations which may occur, the

mechanism of their production and the radiologic means for their demonstration.

The material is well documented with presentation of case histories, the pertinent roentgenologic findings and photographs of the pathologic specimens. The text is concise and the illustrations are beautifully reproduced.

The book is highly recommended to those interested in neurologic problems and also as a valuable reference source.

J. L. LÉGER, M.D.

BOOKS RECEIVED

DIAGNOSIS and TREATMENT of ACUTE RADIATION INJURY. Proceedings of a Scientific Meeting jointly sponsored by the International Atomic Energy Agency and the World Health Organization. Cloth. Price, \$8.00. Pp. 425 with numerous illustrations. International Documents Service, Columbia University Press, 2960 Broadway, New York 27, N. Y., 1961.

WEITERENTWICKLUNG DER ZELLPHYSIOLOGISCHEN METHODEN. ANGEWANDT AUF KREBS, PHOTOSYNTHESE UND WIRKUNGSWEISE DER RÖNTGENSTRAHLEN. By Otto Heinrich Warburg, Direktor des Max-Planck-Instituts für Zellphysiologie. Cloth. Price, \$35.00. Pp. 644 with 177 illustrations. Georg Thieme Verlag, Herdweg 63, Stuttgart, Germany, 1962. In the U.S.A., Interscience Publishers, New York, N. Y., 1962.

JUVENILE RHEUMATOID ARTHRITIS. By Albert W. Grokoeest, M.D., Assistant Clinical Professor of Medicine; Arthur I. Snyder, M.D., Assistant in Medicine; and Ralph Schlaeger, M.D., Assistant Professor of Radiology. Cloth. Price, \$6.50. Pp. 120, with numerous illustrations. Medical Book Department, Little, Brown and Company, Boston 6, Mass., 1962.

SYMPOSIUM ON RECOVERY OF CELLS FROM INJURY. Sponsored by The Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Paper. Pp. 248. The Wistar Institute of Anatomy and Biology, Philadelphia, Pa., 1961.

CARCINOMA OF THE UTERINE CERVIX, ENDOMETRIUM AND OVARY. A Collection of Papers Presented at the Fifth Annual Clinical Conference on Cancer, 1960 at The University of Texas M. D. Anderson Hospital and Tumor Institute, Houston, Texas. Cloth. Price, \$8.50. Pp. 362 with numerous illustrations. Year Book Medical Publishers, Inc., 200 East Illinois Street, Chicago, Ill., 1962.

CLINICAL RADIOLOGY OF THE OESOPHAGUS. By Marcel Brombart, Director of the Department of Radio-diagnosis at the César de Paepe Clinic, Brussels. Translated by Sheila Kenny, M.A., M.D. (Dubl.), Consultant Radiologist, Armagh City Hospital. Cloth. Price, \$15.00. Pp. 383 with numerous illustrations. The William & Wilkins Company, Baltimore 2, Md., 1961.

SOCIETY PROCEEDINGS

MEETINGS OF RADIOLOGICAL SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY

Secretary, Dr. C. Allen Good, Mayo Clinic, Rochester, Minn. Annual meeting: Shoreham Hotel, Washington, D. C., Oct. 2-5, 1962.

AMERICAN RADIUM SOCIETY

Secretary, Dr. Charles G. Stetson, 350 Engle Street, Englewood, N. J. Annual meeting: Mark Hopkins Hotel, San Francisco, Cal., April 2-4, 1963.

RADIOLOGICAL SOCIETY OF NORTH AMERICA

Secretary, Maurice Doyle Frazer, 1744 South Fifty-eighth St., Lincoln, Neb.

Treasurer, Dwight Vincent Needham, 713 E. Genessee St., Syracuse, N. Y. Annual meeting: Palmer House, Chicago, Nov. 25-30, 1962.

AMERICAN COLLEGE OF RADIOLOGY

Executive Director, William C. Stronach, 20 N. Wacker Drive, Chicago 6, Illinois. Annual meeting: Drake Hotel, Chicago, Ill., Feb. 6-9, 1963.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION

Secretary, Dr. Clyde A. Stevenson, Sacred Heart Hospital, West 101 Eighth Ave., Spokane 4, Wash. Annual meeting: Chicago, Ill., June 24-28, 1962.

AMERICAN BOARD OF RADIOLOGY

Secretary, Dr. H. Dabney Kerr. Correspondence should be directed to Kahler Hotel Building, Rochester, Minn. The Spring 1962 examination will be held at the Terrace Hilton Hotel, Cincinnati, Ohio, June 18-22, 1962 inclusive. The deadline for filing applications was January 1, 1962. A special examination in Nuclear Medicine for Diplomates in Radiology or Therapeutic Radiology and an examination in Radiological Physics will be held if there are sufficient applications. The Fall 1962 examination will be held at the Pioneer Hotel, Tucson, Arizona, the first week in December; the deadline for filing applications is July 1, 1962. Please note that at this session Nuclear Medicine will become a mandatory part of the examination. All candidates, excluding re-examinees, who are applying for examination in Radiology or Therapeutic Radiology for the December, 1962 session or thereafter must submit a *Nuclear Medicine application* in addition to their basic application. This applies even to those applicants whose basic applications are on file but who will not yet have appeared for examination.

AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE

Secretary-Treasurer, Charles S. Simons, University of Michigan Hospital, Ann Arbor, Mich. Annual meeting to be announced.

TENTH INTERNATIONAL CONGRESS OF RADIOLOGY

Secretary-General, Dr. Carleton B. Peirce, Royal Victoria Hospital, Montreal 2, Quebec, Canada. Meets in Montreal, Aug. 26-Sept. 1, 1962.

EIGHTH INTER-AMERICAN CONGRESS OF RADIOLOGY

Counselor for the United States, Dr. J. A. del Regato, Penrose Cancer Hospital, 2200 North Cascade Avenue, Colorado Springs, Colorado. Meeting to be announced.

ALABAMA RADIOLOGICAL SOCIETY

Secretary, Dr. Walter Brower, Birmingham, Ala. Meets time and place Alabama State Medical Association.

AMERICAN NUCLEAR SOCIETY

Executive-Secretary, Octave J. Du Temple, 86 E. Randolph St., Chicago, Ill.

ARIZONA RADIOLOGICAL SOCIETY

Secretary, Dr. Don E. Matthieson, 926 East McDowell Rd., Phoenix, Ariz. Two regular meetings a year. Annual

meeting at time and place of State Medical Association and interim meeting six months later.

ARKANSAS RADIOLOGICAL SOCIETY

Secretary, Dr. Charles W. Anderson, 1108½ Poplar, Pine Bluff, Ark. Meets every three months and also at time and place of State Medical Association.

ASSOCIATION OF UNIVERSITY RADIOLOGISTS

Secretary, Dr. Herbert M. Stauffer, Temple University Medical Center, Philadelphia 40, Pa. Annual Meeting: University of Indiana, Indianapolis, Ind., May 19-20, 1962.

ATLANTA RADIOLOGICAL SOCIETY

Secretary, Dr. Wilson T. Edenfield, 35 Linden Ave., N.E., Atlanta 8, Ga. Meets monthly, except during three summer months, on second Friday evening.

BLOCKLEY RADIOLOGICAL SOCIETY

Secretary, Dr. Bernard J. Ostrum, 2412 North 52nd St., Philadelphia, Pa.

BROOKLYN RADIOLOGICAL SOCIETY

Secretary, Dr. Leslie L. Alexander, 257 New York Ave., Brooklyn 16, N. Y. Meets first Thursday of each month October through May.

BUFFALO RADIOLOGICAL SOCIETY

Secretary, Dr. R. Joseph Naples, 106 Morgan Parkway, Williamsville 21, N. Y. Meets second Monday evening each month, October to May inclusive.

CENTRAL NEW YORK RADIOLOGICAL SOCIETY

Secretary, Dr. Edward W. Carsky, Crouse-Ingersoll Hospital, 820 S. Crouse Ave., Syracuse, N. Y. Meets first Monday each month October through May.

CENTRAL OHIO RADIOLOGICAL SOCIETY

Secretary, Dr. Dana R. Schmidt, 1500 West Third Ave., Columbus, Ohio. Meets at 6:30 P.M. on second Thursday of October, November, January, March and May at Fort Hayes Hotel, Columbus, Ohio.

CENTRAL SOCIETY OF NUCLEAR MEDICINE

Secretary, Dr. Robert S. Landauer, Radiation Center Building, 1903 West Harrison St., Chicago 12, Ill.

CHICAGO ROENTGEN SOCIETY

Secretary, Dr. William F. Hutson, 5145 N. California Ave., Chicago, Ill. Meets second Thursday of each month, October to April except December at the Sheraton Hotel at 8:00 P.M.

CLEVELAND RADIOLOGICAL SOCIETY

Secretary, Dr. Ward D. Heinrich, Huron Road Hospital, Cleveland 12, Ohio. Meetings at 7:00 P.M. on fourth Monday of each month from October to April at Tudor Arms Hotel.

COLORADO RADIOLOGICAL SOCIETY

Secretary, Dr. Seward Imes, 1845 High St., Denver, Colo. Meets third Friday of each month at Denver Athletic Club from September through May.

CONNECTICUT VALLEY RADIOLOGICAL SOCIETY

Secretary, Dr. James L. Krieger, 85 Jefferson St., Hartford 6, Conn. Meets first Friday in February and April.

DALLAS-FORT WORTH RADIOLOGICAL SOCIETY

Secretary, Dr. Robert D. Moreton, 816 Medical Arts Bldg., Fort Worth, Texas. Meets monthly, third Monday, at Greater Fort Worth International Airport at 6:30 P.M.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY

Secretary, Dr. Kenneth L. Krabbenhoft, Harper Hospital, Detroit 1, Mich. Meets monthly, first Thursday, October through May, at David Whitney House, 1010 Antietam, at 6:30 P.M.

* Secretaries of societies are requested to send timely information promptly to the Editor.

EAST BAY ROENTGEN SOCIETY

Secretary, Dr. Dan Tucker, 434 30th St., Oakland 9, Calif. Meets first Thursday each month at Peralta Hospital, Oakland.

EAST TENNESSEE RADIOLOGICAL SOCIETY

Secretary, Dr. J. Marsh Frere, Jr., 205 Medical Arts Building, Knoxville, Tenn. Meets in January and September.

EASTERN CONFERENCE OF RADIOLOGY

Secretary, Arrangements Committee, Dr. Bernard S. Wolf, The Mount Sinai Hospital, 11 E. 100 Street, New York 29, N. Y. Annual meeting to be announced.

EASTERN RADIOLOGICAL SOCIETY

Secretary, Dr. James F. Martin, North Carolina Baptist Hospital, Winston-Salem, N. C. Meets at Mid Pines Club, Southern Pines, N. C., April 29-May 2, 1962.

FLORIDA RADIOLOGICAL SOCIETY

Secretary, Dr. Richard D. Shapiro, 1680 Meridian Ave., Miami Beach, Fla. Meets twice annually, in the spring with the annual State Society Meeting, and in the fall.

FLORIDA WEST COAST RADIOLOGICAL SOCIETY

Secretary-Treasurer, Dr. Joseph C. Rush, 1800 Druid Rd., Clearwater, Fla.

GEORGIA RADIOLOGICAL SOCIETY

Secretary, Dr. George W. Brown, Griffin, Ga. Meets in spring and fall with Annual State Society Meeting.

GREATER MIAMI RADIOLOGICAL SOCIETY

Secretary, Dr. T. Hunter Pryor, Jackson Memorial Hospital, Miami 36, Fla. Meets monthly, third Wednesday, at 8:00 P.M. at Jackson Memorial Hospital, Miami, Fla.

GREATER ST. LOUIS SOCIETY OF RADIOLOGISTS

Secretary, Dr. William E. Powers, St. Louis, Mo.

HOUSTON RADIOLOGICAL SOCIETY

Secretary, Dr. John Douglas Reeve, Texas Medical Center Library, Jesse H. Jones Library Bldg., Houston 25, Texas. Meets last Monday each month, Seminar Room, Doctors' Club of Houston.

IDAHOO STATE RADIOLOGICAL SOCIETY

Secretary, Dr. George H. Harris, Bannock Memorial Hospital, Pocatello, Idaho. Meets in the spring and fall.

ILLINOIS RADIOLOGICAL SOCIETY

Secretary, Dr. George A. Miller, Carle Hospital Clinic, Urbana, Ill. Meets in the spring and fall.

INDIANA ROENTGEN SOCIETY, INC.

Secretary, Dr. David E. Wheeler, 1500 North Ritter, Indianapolis 19, Ind. Meets first Sunday in May and during fall meeting of Indiana State Medical Association.

IOWA RADIOLOGICAL SOCIETY

Secretary, Dr. L. L. Maher, 1419 Woodland Ave., Des Moines, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. The scientific section is held in the autumn.

KANSAS RADIOLOGICAL SOCIETY

Secretary, Dr. Roger K. Wallace, Riley County Hospital, Manhattan, Kansas. Meets in spring with State Medical Society, and in winter on call.

KENTUCKY RADIOLOGICAL SOCIETY

Secretary, Dr. Lawrence A. Davis, 226 East Chestnut St., Louisville, Ky. Meets monthly on second Friday at Sheraton Hotel, Louisville.

KINGS COUNTY RADIOLOGICAL SOCIETY

Secretary, Dr. Abraham Berens, 1313 Bedford Ave., Brooklyn 25, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:45 P.M.

LOS ANGELES RADIOLOGICAL SOCIETY

Secretary, Dr. Saul Heiser, Los Angeles, Calif. Meets second Wednesday of month in September, November, January, March and June at Los Angeles County Medical Association Building, Los Angeles.

MAINE RADIOLOGICAL SOCIETY

Secretary, Dr. Albert A. Poulin, Thayer Hospital, Water-

ville, Maine. Meets in June, September, December and April.

MARYLAND RADIOLOGICAL SOCIETY

Secretary, Dr. Nathan B. Hyman, 1805 Eutaw Place, Baltimore 17, Md.

MEMPHIS ROENTGEN SOCIETY

Secretary, Dr. Irving K. Ettman, Kennedy V.A. Hospital, Department of Radiology, Memphis 15, Tenn. Meets first Monday of each month at John Gaston Hospital.

MIAMI VALLEY RADIOLOGICAL SOCIETY

Secretary, Dr. William D. Roberts, 2197 Los Arrow Dr., Dayton 9, Ohio. Meets second Friday of fall and winter months.

MID-HUDSON RADIOLOGICAL SOCIETY

Secretary, Dr. Joseph Sorrentino, St. Francis Hospital, Poughkeepsie, N. Y. Meets 8:30 P.M., fourth Wednesday each month, September to May.

MILWAUKEE ROENTGEN RAY SOCIETY

Secretary, Dr. Abraham Marck, Mayfair Professional Bldg., Milwaukee 13, Wis. Meets monthly on fourth Monday, October through May, at University Club.

MINNESOTA RADIOLOGICAL SOCIETY

Secretary, Dr. Donald H. Peterson, 853 Medical Arts Bldg., Minneapolis 2, Minn. Meets three times annually, in fall, winter and spring.

MISSISSIPPI RADIOLOGICAL SOCIETY

Secretary, Dr. Jack K. Goodrich, University Medical Center, Jackson, Miss. Meets third Thursday of each month at the Heidelberg Hotel, Jackson, at 6:00 P.M.

MONTANA RADIOLOGICAL SOCIETY

Secretary, Dr. John M. Fritts, 1224 S. Higgins Ave., Missoula, Montana. Meets at least once a year.

NASSAU RADIOLOGICAL SOCIETY

Secretary, Dr. Robert Tugendhaft, 100 Nowbridge Rd., Hicksville, N. Y. Meets second Tuesday of the month in February, April, June, October and December.

NEBRASKA STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Richard Bunting, The Radiologic Center, Nebraska Methodist Hospital, Omaha 31, Nebraska. Meets third Wednesday of each month at 6 P.M. in Omaha or Lincoln.

NEVADA RADIOLOGICAL SOCIETY

Secretary, Dr. George F. Fraser, Las Vegas, Nev.

NEW ENGLAND ROENTGEN RAY SOCIETY

Secretary, Dr. Robert E. Wise, 605 Commonwealth Ave., Boston 15, Mass. Meets third Friday of each month, October through April at The Longwood Towers, Brookline, Mass.

NEW HAMPSHIRE ROENTGEN RAY SOCIETY

Secretary, Dr. Paul Y. Hassserjian, 1470 Elm St., Manchester, N. H. Meets four to six times yearly.

NEW YORK ROENTGEN SOCIETY

Secretary, Dr. Bernard S. Wolf, Mt. Sinai Hospital, New York, N. Y. Meets monthly on third Monday at the New York Academy of Medicine at 4:30 P.M.

NORTH CAROLINA RADIOLOGICAL SOCIETY

Secretary, Dr. A. B. Croom, 624 Quaker Lane, High Point, N. C. Meets in the spring and fall each year.

NORTH DAKOTA RADIOLOGICAL SOCIETY

Secretary, Dr. John Jestadt, Depuy-Sorkness Clinic, Jamestown, North Dakota. Meets at time of State Medical Association meeting. Other meetings arranged on call of the President.

NORTH FLORIDA RADIOLOGICAL SOCIETY

Secretary, Dr. Charles H. Newell, 800 Miami Road, Jacksonville 7, Fla. Meets quarterly in March, June, September and December.

NORTHEASTERN NEW YORK RADIOLOGICAL SOCIETY

Secretary, Dr. Lester I. Citrin, St. Mary's Hospital, Troy, N. Y. Meets in Albany area on second Wednesday of October, November, March and April.

NORTHERN CALIFORNIA RADIOLOGICAL SOCIETY

Secretary, Dr. Rob H. Kirkpatrick, 1219 28th St., Sacramento, Calif. Meets at dinner last Monday of each month, September to June.

NORTHWESTERN OHIO RADIOLOGICAL SOCIETY

Secretary, Dr. Anthony F. Lalli, 421 Michigan St., Toledo, Ohio.

OHIO STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Chapin Hawley, 927 Carew Tower, Cincinnati, Ohio. Annual meeting May 25-27, 1962 in Akron.

OKLAHOMA STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Simon Pollack, Utica Square Medical Center, Tulsa, Okla. Meets in January, May and October.

OREGON RADIOLOGICAL SOCIETY

Secretary, Dr. George R. Satterwhite, Willamette Falls Community Hospital, 15th and Division, Oregon City, Ore. Meets monthly from October to June on the second Wednesday of each month at 8:00 P.M. at the University Club.

ORLEANS PARISH RADIOLOGICAL SOCIETY

Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets second Tuesday of each month.

PACIFIC NORTHWEST RADIOLOGICAL SOCIETY

Secretary, Dr. John N. Burkey, 555 Dental Bldg., Seattle, Wash. Annual meeting: Seattle, Washington.

PACIFIC ROENTGEN SOCIETY

Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco 8, Calif. Meets annually during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY

Secretary, Dr. Frederick R. Gilmore, Clearfield Hospital, Clearfield, Pa. Annual meeting: Pocono Manor Inn, May 25-26, 1962.

PHILADELPHIA ROENTGEN RAY SOCIETY

Secretary, Dr. Robert B. Funch, Department of Radiology, Germantown Hospital, Philadelphia 44, Pa. Meets first Thursday of each month, at 5 P.M., from October to May in Thompson Hall, College of Physicians.

PITTSBURGH ROENTGEN SOCIETY

Secretary, Dr. Ross H. Smith, St. Margaret Memorial Hospital, Forty-Sixth St., Pittsburgh 1, Pa. Meets second Wednesday of month, October through June at Park Schenely Restaurant.

RADIOLOGICAL SECTION, BALTIMORE MEDICAL SOCIETY

Secretary, Dr. James K. V. Willson, 1100 N. Charles St., Baltimore 1, Md. Meets third Tuesday each month, September to May, inclusive.

RADIOLOGICAL SOCIETY OF GREATER CINCINNATI

Secretary, Dr. William C. Duffey, Cincinnati, Ohio. Meets monthly from September to May on first Monday of each month at 7:30 P.M. at the Cincinnati General Hospital.

RADIOLOGICAL SOCIETY OF HAWAII

Secretary, Dr. G. J. Liese, Queen's Hospital, Honolulu, Hawaii. Meets third Monday of each month at 7:30 P.M.

RADIOLOGICAL SOCIETY OF GREATER KANSAS CITY

Secretary, Dr. J. Stewart Whitmore, 1010 Rialto Bldg., Kansas City, Mo. Meets last Friday of each month.

RADIOLOGICAL SOCIETY OF KANSAS CITY

Secretary, Dr. Arthur B. Smith, 800 Argle Bldg., Kansas City, Mo. Meets third Thursday of each month.

RADIOLOGICAL SOCIETY OF LOUISIANA

Secretary, Dr. Robyn Hardy, 4324 Magnolia St., New Orleans 15, La. Meets annually during Louisiana State Medical Society meeting.

RADIOLOGICAL SOCIETY OF NEW JERSEY

Secretary, Dr. George H. Burke, 601 Grand Ave., Asbury Park, N. J. Meets at Atlantic City at time of State Medical Society meeting and in November in Newark, N. J.

RADIOLOGICAL SOCIETY OF THE STATE OF NEW YORK

Secretary-Treasurer, Dr. John W. Colgan, 273 Hollywood Ave., Rochester 18, N. Y. Annual meeting to be announced.

RADIOLOGICAL SOCIETY OF SOUTH DAKOTA

Secretary-Treasurer, Dr. Donald J. Peik, 303 S. Minnesota Ave., Sioux Falls, S. D.

RADIOLOGICAL SOCIETY OF SOUTHERN CALIFORNIA

Secretary, Dr. Robert Scanlan, St. Vincent's Hospital, Los Angeles, Calif.

REDWOOD EMPIRE RADIOLOGICAL SOCIETY

Secretary, Dr. Lee E. Tus, 164 W. Napa St., Sonoma, Calif. Meets second Monday every other month.

RICHMOND COUNTY RADIOLOGICAL SOCIETY

Secretary, Dr. W. F. Hamilton, Jr., University Hospital, Augusta, Ga. Meets first Thursday of each month at various hospitals.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.

Secretary, Dr. Harry J. Pinsky, 386 Monroe Ave., Rochester 7, N. Y. Meets at 8:15 P.M. on the last Monday of each month, September through May, at Strong Memorial Hospital.

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY

Secretary, Dr. John H. Freed, 4200 East Ninth Ave., Denver 20, Colo. Annual meeting: Denver Hilton Hotel, Denver, Colo., Aug. 16-18, 1962.

SAN ANTONIO-MILITARY RADIOLOGICAL SOCIETY

Secretary, Dr. Hugo F. Elmendorf, Jr., 730 Medical Arts Bldg., San Antonio 5, Texas. Meets third Wednesday each month in Fort Sam Houston Officer's Club at 6:30 P.M.

SAN DIEGO RADIOLOGICAL SOCIETY

Secretary, Dr. Charles G. Campbell, 6673 Avenida Manana, La Jolla, Calif. Meets first Wednesday of each month at the University Club.

SAN FRANCISCO RADIOLOGICAL SOCIETY

Secretary, Dr. Walter Coulson, San Francisco General Hospital, San Francisco 3, Calif. Meets quarterly at the San Francisco Medical Society, 250 Masonic Ave., San Francisco 18, Calif.

SECTION ON RADIOLOGY, CALIFORNIA MEDICAL ASSOCIATION

Secretary, Dr. William H. Graham, 630 East Santa Clara St., San Jose, Calif.

SECTION ON RADIOLOGY, CONNECTICUT STATE MEDICAL SOCIETY

Secretary, Dr. Wayne P. Whitcomb, Hospital of St. Raphael, New Haven, Conn. Meetings are held bi-monthly.

SECTION ON RADIOLOGY, MEDICAL SOCIETY OF THE DISTRICT OF COLUMBIA

Secretary, Dr. William E. Sheely, 1746 K St., N.W., Washington 6, D. C. Meets at Medical Society Library, third Wednesday of January, March, May and October at 8:00 P.M.

SECTION ON RADIOLOGY, ILLINOIS STATE MEDICAL SOCIETY

Secretary, Dr. William Meszaros, 1825 W. Harrison St., Chicago, Ill.

SECTION ON RADIOLOGY, SOUTHERN MEDICAL ASSOCIATION

Secretary, Dr. Seymour Ochsner, Ochsner Clinic, 3503 Prytania St., New Orleans 15, La. Annual meeting to be announced.

SHREVEPORT RADIOLOGICAL CLUB

Secretary, W. R. Harwell, 608 Travis St., Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M., September to May inclusive.

SOCIETY FOR PEDIATRIC RADIOLOGY

Secretary, Dr. Richard C. Lester, 412 Union St., S.E., Minneapolis 14, Minn. Annual meeting: Shoreham Hotel, Washington, D. C., Sept. 30-Oct. 1, 1962.

SOCIETY OF NUCLEAR MEDICINE

Secretary, Dr. Robert W. Lackey, 452 Metropolitan Bldg., Denver 2, Colo. *Administrator*, Samuel N. Turiel, 430 N. Michigan Ave., Chicago 11, Ill. Annual meeting: Baker Hotel, Dallas, Texas, June 26-29, 1962.

SOUTH BAY RADIOLOGICAL SOCIETY

Secretary, Northern Section: Dr. John S. Wilson, 1515 Trousdale Dr., Burlingame, Cal.; Southern Section: Dr. A. C. Mitchell, 728 Cass, Monterey, Cal. Meets second Wednesday of each month.

SOUTH CAROLINA RADIOLOGICAL SOCIETY

Secretary, Dr. George W. Brunson, 1406 Gregg St., Columbia, S. C. Annual meeting (primarily business) in conjunction with the South Carolina Medical Association meeting in May. Annual fall scientific meeting at time and place designated by the president.

SOUTHERN RADIOLOGICAL CONFERENCE

Secretary, Dr. Marshall Eskridge, Mobile Infirmary, P.O. Box 4097, Mobile, Ala. Annual meeting: Grand Hotel, Point Clear, Alabama, Feb. 1-3, 1963.

SOUTHWESTERN RADIOLOGICAL SOCIETY

Secretary, John M. McGuire, 904 Chelsea, El Paso, Texas. Meets last Monday of each month at 6:30 P.M. in the Paso del Norte Hotel.

TENNESSEE RADIOLOGICAL SOCIETY

Secretary, Dr. B. M. Brady, St. Joseph Hospital, Memphis, Tenn. Meets annually at the time and place of the Tennessee State Medical Association meeting.

TEXAS RADIOLOGICAL SOCIETY

Secretary, Dr. R. P. O'Bannon, 402 Professional Bldg., 1216 Pennsylvania Ave., Fort Worth 4, Texas. Annual meeting: San Antonio, Texas, Jan. 25 and 26, 1963.

TRI-STATE RADIOLOGICAL SOCIETY

Secretary, Dr. John H. Marchand, Jr., Welborn Clinic, 420 Cherry St., Evansville, Ind. Meets third Wednesday of Oct., Jan., March and May, 8:00 P.M., Elks Club in Evansville.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING

Meets each Monday evening from September to June, at 7:00 P.M. at University Hospital.

UPPER PENINSULA RADIOLOGICAL SOCIETY

Secretary, Dr. A. Gonty, Menominee, Mich. Meets quarterly.

UTAH STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Richard Y. Card, St. Mark's Hospital, Salt Lake City, Utah. Meets fourth Wednesday in January, March, May, September and November at Holy Cross Hospital.

VERMONT RADIOLOGICAL SOCIETY

Secretary, Dr. John R. Williams, 160 Allen St., Rutland, Vt.

VIRGINIA RADIOLOGICAL SOCIETY

Secretary, Dr. Powell G. Dillard, Jr., 715 Church Street, Lynchburg, Va. Meets annually in October.

WASHINGTON STATE RADIOLOGICAL SOCIETY

Secretary, Dr. Joseph T. Houk, 14303 Ambaum Blvd., Seattle 66, Wash. Meets third Monday of each month from September through April at the University of Washington Medical School.

WEST VIRGINIA RADIOLOGICAL SOCIETY

Secretary, Dr. Karl J. Myers, The Myers Clinic-Broadus Hospital, Philippi, W. Va. Meets concurrently with Annual Meeting of West Virginia State Medical Society; other meetings arranged by program committee.

WESTCHESTER RADIOLOGICAL SOCIETY

Secretary, Dr. Anthony A. Maglione, Westchester Academy of Medicine, Section on Radiology, Purchase, N. Y. Meets on third Tuesday of January and October and on two other dates.

WISCONSIN RADIOLOGICAL SOCIETY

Secretary, Dr. Howard G. Bayley, 116 Iroquois Parkway, Beaver Dam, Wis. Annual meeting each spring in various places.

CUBA, MEXICO, PUERTO RICO AND CENTRAL AMERICA

ASOCIACIÓN DE RADIOLOGOS DE CENTRO AMERICA Y PANAMÁ. Comprising: Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panamá.

Secretary-General, Dr. Julio Toriello, 11 Calle 2-37, Zona 1, Guatemala. Meets annually in a rotating manner in the six countries.

SOCIEDAD DE RADIOLOGÍA DE EL SALVADOR

Secretary, Dr. Rafael Vaga Gómez.

SOCIEDAD DE RADIOLOGÍA DE GUATEMALA

Secretary, Dr. Carlos E. Escobar, 9^a Calle A 0-05, Zona 1, Guatemala.

SOCIEDAD DE RADIOLOGÍA Y FISIOTERAPIA CUBANA

Secretary, Dr. Miguel A. García Plasencia, Hospital Curie, 29 y F, Vedado, Habana, Cuba. Meets monthly at Curie Hospital.

SOCIEDAD COSTARRICENSE DE RADIOLOGIA

Secretary, Dr. James Fernández Carballo, Apartado VIII, San José, Costa Rica.

SOCIEDAD MEXICANA DE RADIOLOGÍA, A. C.

Calle del Oro No. 15, México 7, D. F.

Secretary-General, Dr. E. Alvarez Hernández. Meets first Monday of each month.

ASOCIACIÓN PUERTORRIQUEÑA DE RADIOLOGÍA

Secretary, Dr. R. B. Díaz Bonnet, Suite 504, Professional Bldg., Santurce, Puerto Rico.

SOCIEDAD RADIOLOGICA PANAMEÑA

Secretary, Dr. L. Arrieta Sánchez, Apartado No. 6323, Panamá, R. de P. Meets monthly in a department of radiology of a local hospital, chosen at preceding meeting.

SOCIEDAD RADIOLOGICA DE PUERTO RICO

Secretary, Dr. César E. Rosa-Perez, Fondo del Seguro del Estado, Parada 1, San Juan 8, Puerto Rico. Meets second Thursday of each month at 8:00 P.M. at the Puerto Rico Medical Association Bldg. in San Juan.

BRITISH COMMONWEALTH OF NATIONS

ASSOCIATION OF RADIOLOGISTS OF THE PROVINCE OF QUEBEC

Secretary, Dr. Odilon Raymond, 5400 Blvd. Gouin, Ouest, Montreal, Que. Meets four times a year.

BRITISH INSTITUTE OF RADIOLOGY

Honorary Secretary, Dr. R. D. Hoare, 32 Welbeck St., London, W. 1. Meets monthly from October until May.

EDMONTON AND DISTRICT RADIOLOGICAL SOCIETY

Secretary, Dr. S. C. Windle, 105 Northgate Bldg., Edmonton, Alberta. Meets first Tuesday of each month. October to May.

FACULTY OF RADIOLOGISTS

Honorary Secretary, Dr. C. J. Hodson, 47 Lincoln's Inn Fields, London, W.C.2, England. Annual meeting: Hammersmith Hospital and the Postgraduate Medical School, London, June 15-16, 1962.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)

Meets third Friday each month at 4:45 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

CANADIAN ASSOCIATION OF RADIOLOGISTS

Honorary Secretary, Dr. Robert G. Fraser, *Associate Honorary Secretary*, Dr. D. J. Sieniewicz, 1555 Summerhill Ave., Montreal 25, Que. Annual meeting: to be announced.

MONTREAL RADIOLOGICAL STUDY CLUB

Secretary, Dr. F. McConnell, 1650 Cedar Ave., Montreal, Quebec. Meets first Tuesday evening, October to April.

SECTION OF RADIOLOGY, CANADIAN MEDICAL ASSOCIATION

Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S.

SOCIÉTÉ CANADIENNE-FRANÇAISE D'ELECTRO-RADIOLOGIE MÉDICALE

General Secretary, Dr. Maurice Dufresne, 1560 Sherbrooke (East), Montreal, Canada. Meets third Saturday each month.

TORONTO RADIOLOGICAL SOCIETY

Secretary, Dr. Wallace M. Roy, St. Joseph's Hospital, 30 The Queensway, Toronto 3, Ontario. Meets second Monday of each month September through May.

COLLEGE OF RADIOLOGISTS OF AUSTRALIA

Honorary Secretary, Dr. E. A. Booth, c/o British Medical Agency, 135 Macquarie St., Sydney, N.S.W., Australia.

SOUTH AMERICA

ASOCIACIÓN ARGENTINA DE RADIOLOGÍA

Secretary, Dr. Lidio G. Mosca, Avda. Gral. Paz 151, Córdoba, Argentina. Meetings held monthly.

ATENEO DE RADIOLOGIA

Secretary, Dr. Victor A. Añafios, Instituto de Radiología, Santa Fe 3100, Rosario, Argentina. Meets monthly on second and fourth Fridays at 7:00 P.M. in the Hospital Nacional del Centenario, Santa Fe 1300, Rosario.

COLÉGIO BRASILEIRO DE RADIOLOGIA

Secretary-General, Dr. Tede Eston de Eston, Caixa Postal 5984, São Paulo, Brazil.

SOCIEDAD ARGENTINA DE RADIOLOGÍA, JUNTA CENTRAL, BUENOS AIRES

Secretary, Dr. Edgardo O. Olcese, Santa Fé 1171, Buenos Aires. Meetings are held monthly.

SOCIEDAD BOLIVIANA DE RADIOLOGÍA

Secretary, Dr. Javier Prada Méndez, Casilla 1596, La Paz, Bolivia. Meets monthly. General assembly once every two years.

SOCIEDADE BRASILEIRA DE RADIOLOGIA

Secretary, Dr. Nicola Caminha, Av. Mem. de Sa, Rio de Janeiro, Brazil. General Assembly meets every two years in December.

SOCIEDADE BRASILEIRA DE RADIOTERAPIA

Secretary, Dr. Oscar Rocha von Pfuhl, Av. Brigadeiro Luiz Antonio, 644 São Paulo, Brazil. Meets monthly on second Wednesday at 9:00 P.M. in São Paulo at Av. Brigadeiro Luiz Antonio, 644.

SOCIEDAD CHILENA DE RADIOLOGÍA

Secretary, Dr. J. P. Velasco, Avenida Santa María 0410, Santiago, Chile. Meets fourth Friday of each month.

SOCIEDAD COLOMBIANA DE RADIOLOGIA

Secretary, Dr. Alberto Mejía Diazgranados, Carrera 13, No. 25-31, Apartado aéreo No. 5804, Bogotá, Colombia. Meets last Thursday of each month.

SOCIEDAD ECUATORIANA DE RADIOLOGÍA Y FISIOTERAPIA

Secretary, Dr. Publio Vargas P., Casilla 1242, Guayaquil, Ecuador.

SOCIEDAD PARAGUAYA DE RADIOLOGÍA

Secretary, Dr. Miguel González Addone, 15 de Agosto 322, Asunción, Paraguay.

SOCIEDAD PERUANA DE RADIOLOGIA

Secretary, Dr. Luis Pinillos Ganoza, Apartado 2306, Lima, Peru. Meets monthly except during January, February and March, at Asociación Médica Peruana "Daniel A. Carrión," Villalta 218, Lima.

SOCIEDAD DE RADIOLOGIA DEL ATLANTICO

Secretary, Dr. Raul Fernandez, Calle 40 #41-110, Baranquilla, Colombia. Society meets monthly at the Instituto de Radiologia.

SOCIEDAD DE RADIOLOGÍA, CANCEROLOGÍA Y FÍSICA MÉDICA DEL URUGUAY

Secretary-General, Dr. Ernesto H. Cibils, Av. Agraciada 1464, piso 13, Montevideo, Uruguay.

SOCIEDADE DE RADIOLOGIA DE PERNAMBUCO

Secretary, Dr. Manoel Medeiros, Instituto de Radiologia da Faculdade de Medicina da Universidade do Recife, Caixa Postal 505, Pernambuco, Brazil.

SOCIEDAD DE ROENTGENOLOGIA Y MEDICINA NUCLEAR DE LA PROVINCIA DE CÓRDOBA

Secretary-General, Dr. Carlos A. Oulton, Santa Rosa 447, Córdoba, Argentina.

SOCIEDAD VENEZOLANA DE RADIOLOGÍA

Secretary-General, Dr. Rubén Merensfeld, Apartado No. 9362, Candelaria, Caracas, Venezuela. Meets monthly third Friday at Colegio Médico del Distrito Federal, Caracas.

CONTINENTAL EUROPE**ÖSTERREICHISCHE RÖNTGEN-GESELLSCHAFT**

President, Dr. Konrad Weiss, Mariannengasse 10, Vienna 9, Austria. Meets second Tuesday of each month in Allgemeine Poliklinik.

SOCIÉTÉ BELGE DE RADIOLOGIE

General Secretary, Dr. S. Masy, 256 Chaussée de Wavre, Heverlee-lez-Louvain, Belgium. Meets in February, March, May, June, October, November and December.

SOCIÉTÉ FRANÇAISE D'ELECTRORADIOLOGIE MÉDICALE, and its branches: **SOCÉTÉ DU SUD-OUEST, DU LITTORAL MÉDITERRANÉEN, DU CENTRE ET DU LYONNAIS, DU NORD, DE L'OUEST, DE L'EST, ET D'ALGER ET D'AFRIQUE DU NORD**. Central Society meets third Monday of each month, except during July, August and September, rue de Seine 12, Paris.

Secretary-General, Dr. Ch. Proux, 9 rue Daru, Paris 8^e, France.

ČESKOSLOVENSKÁ SPOLEČNOST PRO ROENTGENOLOGII A RADIOLOGII

Secretary, Dr. Robert Poch, Praha 12, Šrobárova 50, Czechoslovakia. Meets monthly except during July, August, and September. Annual general meeting.

DEUTSCHE RÖNTGENGESELLSCHAFT

Secretary, Professor Dr. med. H. Lossen, Universitäts-Röntgeninstitut, Lagenbeckstr. 1, Mainz, Germany. Annual meeting Köln, Germany, May 7-10, 1962.

SOCIETÀ ITALIANA DI RADIOLOGIA MEDICA E DI MEDICINA NUCLEARE

Secretary, Dr. Ettore Conte, Ospedale Mauriziano, Torino, Italy. Meets annually.

NEDERLANDSE VERENIGING VOOR ELECTROLOGIE EN RÖNTGENOLOGIE

Secretary, Dr. J. R. von Ronnen, Violonweg 14, den Haag, Netherlands.

SCANDINAVIAN ROENTGEN SOCIETIES

The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

SOCIEDAD ESPAÑOLA DE RADIOLOGÍA Y ELECTROLOGÍA MÉDICAS Y MEDICINA NUCLEAR

Secretary, Dr. D. Aureo Gutierrez Churruga, Esparteros, No. 9, Madrid, Spain. Meets monthly in Madrid.

SCHWEIZERISCHE GESELLSCHAFT FÜR RADIOLOGIE UND NUKLEARMEDIZIN (SOCIÉTÉ SUISSE DE RADIOLOGIE ET DE MÉDECINE NUCLÉAIRE)

Secretary, Dr. Max Hopf, Effingerstrasse 47, Bern, Switzerland.

INDIA**INDIAN RADIOLOGICAL ASSOCIATION**

Secretary, Dr. R. F. Sethna, Navsari Building, Hornby Road, Bombay 1, India.



ABSTRACTS OF RADIOLOGICAL LITERATURE

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ROENTGEN DIAGNOSIS

ABDOMEN

FONTAINE, R., WARTER, P., and WEILL, F. Aspect radiologique des sarcomes de l'estomac (à propos de 12 observations). (Radiologic aspect of gastric sarcomas [based on 12 cases].) *J. de radiol., d'électrol. et de méd. nucléaire*, Oct., 1961, 42, 509-517. (From: Clinique Chirurgicale A, Strasbourg, France.)

The term gastric sarcoma is a restrictive one, and does not include gastric locations of Hodgkin's disease or lymphosarcomatosis. The classification is complex, a distinction being made between those tumors showing some differentiation (leiomyoblastic, rhabdomyoblastic, fibroblastic, neuroblastic) and those of adenoid pattern. The latter can be divided into reticular, dictiocytic, plasmocytic, histiocytic, and endothelio-sarcomatous types.

Macroscopically the tumors may be endogastric, infiltrative or exogastric. The endogastric masses cannot be differentiated roentgenographically from carcinomas, whereas the exogastric ones can resemble extrinsic tumors, such as those of hepatic origin. Some possibility exists in differentiating the infiltrative type, since sarcomatous infiltrates do not cause narrowing, as do carcinomatous ones, and may involve the entire lesser curvature, whereas in the authors' experience carcinoma does not.

Treatment of gastric sarcoma consists of surgery, radiotherapy, or both, and with such a management prognosis is better than in carcinoma. The authors' 12 cases of sarcoma constituted 4.7 per cent of the gastric malignancies of their series; the mean survival rate was $7\frac{1}{2}$ years, with several patients still living.—*Frank A. Riebel, M.D.*

MEEROFF, MARCOS, and FERREIRA, JORGE A. La radiología en el diagnóstico de las afecciones del colon derecho. (Radiology in the diagnosis of processes of the right colon.) *Rev. brasil. de gastroenterol.*, May-Aug., 1961, 13, 89-106. (Address: Policlínico de Lánus, Buenos Aires, Argentina.)

The authors review the differential diagnostic signs of processes encountered in the ascending colon during barium enema examination; *i.e.* adhesions, peri-appendiceal abscess, annular carcinoma, and include a few unusual entities—ameboma, Hodgkin's disease and blastomycosis (with case reports).—*E. R. N. Grigg, M.D.*

SCHATZKI, STEFAN C. Hemobilia. *Radiology*, Nov., 1961, 77, 717-721. (Address: Walter Reed Army Hospital, Washington 12, D. C.)

Hemobilia, or hemorrhage into the biliary tract, is an uncommon cause of bleeding into the gastrointestinal tract. Chronic blood loss is occasionally asso-

ciated with neoplasms of the ampulla of Vater, biliary stone, and other lesions of the biliary tract, but is minimal in degree. In contrast, massive hemobilia is a serious bleeding problem producing abdominal pain, melena, hematemesis, and shock. The radiologist must be aware of this problem since operative hepatic arteriography and operative cholangiography are usually necessary to demonstrate the source of bleeding.

The most common causes of massive hemobilia are aneurysm of the hepatic artery and liver trauma. The majority of hepatic artery aneurysms is thought to be secondary to infection with subsequent erosion of the aneurysm into either the biliary tract or both the biliary and the gastrointestinal tracts. In addition to hemobilia, some patients present pain which mimics biliary colic or jaundice. Since preoperative diagnosis is usually impossible, the most effective single procedure is operative hepatic arteriography. In a rare case the correct diagnosis is suggested by liver enlargement with a pulsating tumor, a palpable thrill, and a systolic bruit.

Traumatic hemobilia follows a non-penetrating injury to the liver and is the result of an intrahepatic cavity that periodically empties its contents into the biliary tract. The original trauma undoubtedly results in some necrosis of the liver parenchyma, initiating a cycle of cavitation, vascular oozing, and an increase in cavitary pressure which then discharges into the biliary tract with massive hemorrhage. Characteristically, the hemorrhage is delayed for several weeks after the trauma and is heralded by severe abdominal pain, often biliary in nature, with a reduction in the pain after gross bleeding appears. Jaundice is a common temporary finding. Therefore, in certain cases the diagnosis can be suggested, in the event of antecedent liver trauma, by the symptom-complex of periodic abdominal pain, upper gastrointestinal hemorrhage which tends to relieve the pain, and jaundice. The author presents a well-documented case report of traumatic hemobilia in a $4\frac{1}{2}$ year old female diagnosed by operative cholangiography and cured by left hepatic lobectomy.

The author emphasizes that hemobilia is an uncommon but serious cause of gastrointestinal blood loss. In certain cases, the cause of bleeding may be suspected from clinical findings, but in many cases the diagnosis cannot be made preoperatively. If no other cause for hemorrhage is demonstrated at surgery, the biliary tract should be investigated as a possible source. Should this contain blood, an operative hepatic arteriogram should be obtained and if necessary operative cholangiography should follow.—*Edward B. Best, M.D.*

ARRIETA SANCHEZ, L. Colecistografía por vía rectal. (Cholecystography by the rectal route.) *Radiología*, Dec., 1961, 12, 11-15. (Address: Radiólogo del Hospital Santo Tomás, Panamá, Rep. de Panamá.)

In the same year 1926 in which Graham and Cole first described their (intravenous) procedure for cholecystography, Stegmann and Hermann published their experience with rectal administration of cholecystographic media (*München. med. Wchschr.*, 926, 73, 1281.) but they had discontinued it because it appeared to irritate the mucosa.

Arrieta Sanchez used 8 capsules of Biloptin (Schering) dissolved in 30 cc. of lukewarm water, given as a retention enema. Good visualization of the gallbladder was obtained after 4-5 hours. No significant reactions were encountered.

The method, aside from the shorter time needed, has also the advantage of feasibility in nauseated patients and in children of any age.—*E. R. N. Grigg, M.D.*

GYNECOLOGY AND OBSTETRICS

SHANBHAG, A. M. Pneumoperitoneogynecography; a diagnostic aid, its technique, significance and x-ray appearances in normal and diseased female pelvic organs. *Indian J. M. Sc.*, Feb., 1961, 15, 87-99. (Address: Senior Gynecology Registrar, Lokmanya Tilak Municipal General Hospital, Sion, Bombay 22, India.)

Pneumoperitoneogynecography is an excellent almost harmless gynecologic diagnostic aid. Carbon dioxide in amounts of 1,000 to 1,600 cc. is used, with transabdominal approach preferred. The films are exposed with the patient lying prone, the hips being elevated and the central ray being angled 20° cephalad. The pelvic structures are clearly visualized and any abnormalities can be easily demonstrated. Hysterosalpingography may be combined with gynecography for double contrast effect. After the examination the patient is kept in Trendelenburg position for a few hours to confine the gas to the pelvis. Most patients are entirely symptom-free after 1 to 10 hours.

The procedure is useful in demonstrating congenital anomalies of the genital tract, early pregnancy (normal and abnormal), fibromyomata of the uterus, undefined pelvic masses, and in various other miscellaneous conditions. It is of limited value in carcinoma of the cervix, but may be helpful in this condition in demonstrating the extent of infiltration.

Gynecography is an economic and simple procedure with negligible morbidity if due care is taken in the selection of cases and in technique. In certain instances, it can spare the patient the greater morbidity of laparoscopy, culdoscopy, or exploratory laparotomy. In other cases it will enable the surgeon to approach the operation with greater confidence and with better planning because of more accurate knowledge of existing pathology.

Gynecography is contraindicated in acute pelvic inflammation, severe intraperitoneal hemorrhage, and in very old feeble patients or those with decom-

pensated cardiac and respiratory lesions. The method must be used with caution in cases of possible pregnancy.

Several illustrative cases are presented by the author.—*Leslie K. Sycamore, M.D.*

GENITOURINARY SYSTEM

SHEEHAN, F. RICHARD, LESSMANN, ELLEN M., and LESSMANN, FRANZ P. A comparative study of intraosseous cavography and intravenous pyelography in the demonstration of retroperitoneal lymphoma. *Radiology*, Nov., 1961, 77, 757-763. (Address: Roswell Park Memorial Institute, Buffalo 3, N. Y.)

The retroperitoneal space is the site of a variety of tumors. The lymphatics may be involved by either primary lymphomas or metastatic lesions. In the case of lymphomas the localization of retroperitoneal tumor masses becomes a particular problem. To accomplish this the radiologist has at his command many procedures of varying technical ease and accuracy according to the size and location of the involvement. Two such specialized procedures are intravenous pyelography and intraosseous cavography, opacifying the inferior vena cava by injection of contrast medium into the medullary canal of the spinous process of one of the lower lumbar vertebrae.

The purpose of this article is to report the authors' experiences with intraosseous cavography in evaluating the retroperitoneal space and to compare the results with those of intravenous pyelography. Thirty-four patients with proved lymphoma and possible involvement of the retroperitoneal lymph nodes were examined by both methods: 4 of the positive cases were re-evaluated after treatment. Although most patients complain of some pain during the injection for intraosseous cavography there have been no significant complications. Additional contraindications to this procedure include bone-marrow sclerosis or infiltration which make adequate outlining of the vena cava impossible.

In 21 of the 34 cases there was displacement and/or narrowing of the inferior vena cava as the result of extrinsic pressure, but in only 7 of these patients were changes noted on intravenous pyelography. The intraosseous venographic studies were positive in 12 cases in which pyelography was either negative or failed to outline the ureters satisfactorily. In 4 of these cases, the level of displacement was above the level of the kidneys; in the remaining 8, the lymph nodes were either large enough to cause detectable changes in the vena cava, but not in the ureters, or were more intimately related to the vena cava. Intravenous pyelography was positive in the presence of unsatisfactory intraosseous venograms in only 4 cases. Eight of the intravenous pyelograms were questionably positive, as compared to 3 of the intraosseous venograms. In the 10 patients who came to autopsy within a few months of the examination

with the presence of lymph nodes 2 cm. or more in diameter, there were 1 questionably positive and 6 definitely positive cavograms, whereas there were 3 false negative intravenous pyelograms. Lymph nodes smaller than 2 cm. were not demonstrated by either method. Also in 2 of the cases with unsatisfactory cavograms there was extensive bone-marrow infiltration by tumor which explains the difficulty of injection in these instances.

From the results of these studies it appears that intraosseous cavography is a more accurate procedure for demonstrating retroperitoneal lymphoma; however, the disadvantages are the more involved technical procedure and some discomfort to the patient. The procedure should be reserved for cases where simpler methods have failed.—*Walter H. Jarvis, Jr., M.D.*

SCORER, C. G., and FINLAY, H. V. L. Massive unilateral hydronephrosis in early infancy. *Brit. J. Surg.*, Sept., 1961, 49, 144-148. (From: Hillingdon Hospital, Uxbridge, England.)

The authors report 2 cases of congenital unilateral hydronephrosis due to obstruction at the pelvico-ureteric junction. These patients had abdominal enlargement at birth. Both had large, smooth masses, one could be transilluminated and the other could not. An intravenous pyelogram showed no function on the involved side and normal function on the opposite side. In both cases a nephrectomy was performed.

The authors reviewed the literature and found that abdominal swelling from a renal mass at birth is rare. Multicystic unilateral kidneys are more commonly noted than the smooth mass produced by uretero-pelvic obstruction. If a solid mass is palpated, Wilms' tumor may be considered. The authors recommend early intravenous pyelography in the presence of a mass to evaluate the involved kidney and establish the degree of function of the opposite side.—*George L. Sackett, Jr., M.D.*

SALVIONI, G. F. Sulla branca cieca d'uretere bifido. (Blind branch of the bifid ureter.) *Radiol. med.*, Sept., 1961, 47, 846-849. (Address: Dott. Gianfranco Salvioni, Via Mazzini 8, Bergamo, Italy.)

The blind branch of the bifid ureter is a very rare congenital anomaly which must be distinguished from congenital ureteral diverticulum. In all, 50 cases have been reported; 15 of these by O. S. Culp in 1947. The differentiation is based on the dimensions. Every congenital diverticulum whose length is at least twice its diameter may be considered to be a blind branch.

Embryologically, the blind branch originates from an accessory ureteral center. It has long been established that the urinary tract is primarily mesodermal

in origin. The renal parenchyma derives from the metanephros, the renal pelvis and ureter from the wolffian duct, and the urinary bladder from the urogenital sinus and the allantois.

Histologically, a true distinction from a congenital diverticulum cannot be made. In both instances the fundamental structure is that of a normal ureter.

Clinically its presence may be suspected because of lumbar pain radiating to the pelvis, fever, dysuria and occasionally hematuria. The diagnosis is exclusively roentgenologic. Intravenous and retrograde pyelography will demonstrate the abnormality.—*Anthony A. Blasi, M.D.*

PINCK, BERNARD D. Aneurysms of the aorta simulating urologic disease. *J. Urol.*, Dec., 1961, 86, 798-818. (Address: 203 Passaic Ave., Passaic, N. J.)

Increasing life span has presented the problem of diagnosis and treatment of arteriosclerotic aneurysms of the aorta. This article brings to the attention of the urologist the similarity between the clinical symptomatology of urinary tract disease and aortic aneurysm. By their very nature, aneurysms of the aorta may block the renal arteries or may rupture with consequent hemorrhage and shock. In either event, the patient develops prerenal anuria. In other instances, aneurysms may block or displace the ureters producing ureteral irritation or compression with signs and symptoms of ureteral colic or obstruction. Probably the most significant factor in diagnosis of abdominal aneurysm is the recognition of its occurrence in the elderly individual. Palpation of the abdomen, roentgen ray examination by survey films, retrograde pyelography, or aortography are used to confirm the diagnosis. In any patient with abdominal pain of undetermined nature, the possibility of an aneurysm should be considered. The symptoms which suggest urologic disease are backache, colic, or anuria. The pain may radiate into the flank or into the perineum.

The need for prompt surgical intervention is emphasized, since even ruptured abdominal aneurysms are not necessarily immediately fatal. The surgical treatment of aneurysms of the abdominal aorta by excision and replacement is now generally effective and a true life-saving procedure.

The author includes 14 case reports and 14 illustrations which complement the text.—*G. W. Chamberlin, M.D.*

HAYNIE, THOMAS P., STEWART, BRUCE H., NOFAL, MOHAMMED M., CARR, EDWARD A., and BEIERWALTES, WILLIAM H. (Ann Arbor, Mich.) Renal scintiscans in the diagnosis of renal vascular disease. *J. Nuclear Med.*, Oct., 1961, 2, 272-281.

The search for better diagnostic tests in renal vascular disease has led to application of both radio-

isotope and photoscanning techniques and to the development of renal scintiscans. Both I^{131} hippuran and Hg^{203} neohydrin have been used successfully in renal scans, and their efficacy in detection of renal vascular disease is reported here.

The comparative accuracy of the diagnostic procedures in ability to (a) detect significant ischemia or infarction, and (b) to distinguish unilateral from bilateral disease in order of decreasing accuracy is as follows:

	No. Cases	% Correct
Aortograms	13	85
Hg^{203} Neohydrin Renal Scintiscans	10	80
Renograms	13	69
Pyelograms	14	57
Howard Test	11	56
I^{131} Hippuran Renal Scintiscans	6	17

No test is infallible and each test has its own contribution to make. The authors conclude that the diagnostic accuracy of Hg^{203} neohydrin renal scintiscans compares favorably with other procedures currently used in diagnosis of renal hypertension, whereas I^{131} hippuran renal scintiscans have been disappointing.—*Bernard Loitman, M.D.*

FRANKLIN, DONALD A., and MEADE, ROBERT C. Diagnosis of bilateral pelvic kidneys by means of radiohippuran renogram. *J. Urol.*, Nov., 1961, 86, 514-517. (From: The Radioisotope Service of the Wood Veterans Administration Center and the Marquette University School of Medicine, Milwaukee, Wis.)

The renogram procedure as used by the authors consists of a preliminary intravenous administration of hippuran, 0.03 μ c per kg. of body weight, as a localizing dose. The count rate meter sensitivity is set at 10,000 counts per minute, the time constant at 1.5 seconds, and the recorder is run at 0.75 inches per minute. The scintillation probes are placed over the area of maximum activity of each kidney. After this is done, the count rate meter sensitivity is set at 30,000 counts per minute and the paper speed of the recorder is decreased to 12 inches per hour. The time constant is kept at 1.5 seconds. Another hippuran injection of 0.3 μ c per kg. is given and the renogram is recorded.

The patient, who is the subject of this article, had bilateral pelvic kidneys. In this instance, the renogram shows a normal secretory phase but the excretory phases are obscured by the proximity of the kidneys to the urinary bladder. Confirmation of bilateral pelvic kidneys was made by intravenous pyelograms.

It is noted that placing of the probes blindly is unsatisfactory since it would record only renal blood volume.

Four figures illustrate the normal and variations in the renogram incident to ectopic kidneys.—*G. W. Chamberlin, M.D.*

DON, CONWAY. Unilateral manifestations of bilateral renal artery disease. *Canad. M.A.J.*, Nov., 1961, 85, 1188-1192. (From: The Departments of Radiology, Ottawa General Hospital and University of Ottawa, Ottawa, Canada.)

Increasing use of renal arteriography in the investigation of hypertension has shown that renal artery occlusion is not the rare phenomenon that it was formerly thought to be. Renal arteriography is not, however, a harmless procedure, and it is doubtful whether it is justifiable as a routine form of examination for all hypertensive patients.

The author has attempted to correlate the roentgenologic findings with the renal arteriographic findings. Urographic evidence of depressed function and/or significant asymmetry in length and parenchymal thinning were considered evidence of renal disease.

Twelve cases of renal artery disease are reviewed. Of these, 9 presented on intravenous pyelography with unilateral depression of function and/or significant asymmetry of size, as defined above. Three of the 9 cases are reported in detail because they were demonstrated to have bilateral renal stenosis of a moderate or severe degree in spite of the unilateral findings by urography.

From these cases it appears that bilateral renal artery disease simulates unilateral artery disease in that the intravenous pyelogram may be normal or may show strictly unilateral manifestation of disease. Bilateral roentgenologic manifestation of bilateral renal artery disease seems to be very rare.—*William C. MacCarty, Jr., M.D.*

WILKINSON, F. O. W. Rupture of the posterior urethra; with a review of twelve cases. *Lancet*, May 27, 1961, 1, 1125-1129. (From: Department of Surgery, Manchester Royal Infirmary, Manchester, England.)

Rupture of the posterior urethra is becoming more common with the increase in the number of traffic accidents. It occurs as a complication of a fracture of the pelvis, usually of the pubic bones, as a result of severe crushing injury. The urethra is torn across at the apex of the prostate where the prostatic urethra pierces the rigid superior layer of the triangular ligament. In cases of fractured pelvis, this injury is twice as common as rupture of the bladder. This must be borne in mind in all patients with fractures of the pelvis. Undiagnosed or improperly treated cases may result in urinary infection, stricture, and impotence.

When any doubt exists of the presence of the lesion, urethrography is essential. A thin water-soluble medium will demonstrate irregularities and extravasations in the area of the posterior urethra.

The treatment of choice is repair of the urethra over a Foley catheter which is then put on traction

which is maintained for 10 days. Results in 12 cases seen by the author are reported. Six cases treated as outlined above recovered with minimal complications. Five of 6 cases treated without traction developed complications, including stricture in 3 cases.—*Leslie K. Sycamore, M.D.*

NERVOUS SYSTEM

NEUHAUSER, EDWARD B. D., and KAUFMANN, H. J. (Boston, Mass.) A. O. Kovalevski and the neurenteric canal: a note on some historical inaccuracies. *Proc. Roy. Soc. Med.*, Nov., 1961, 54, 927-929.

The authors point out that there is confusion over the identity of the man who discovered the embryonic structure known as the neurenteric canal. His real name was Alexander Onoufievich Kovalevski. He was an outstanding Russian embryologist who lived from 1840 to 1901. Pavel Ivanovich Kovalevski was born four years later and he was an outstanding neurologist and psychiatrist. Neither he nor Nikolas Opsipobich Kowalevsky should be confused with A. O. Kovalevski who was the real discoverer of the neurenteric canal.—*Arthur E. Childe, M.D.*

SKELETAL SYSTEM

HALL, MICHAEL C. The trabecular patterns of the neck of the femur with particular reference to changes in osteoporosis. *Canad. M.A.J.*, Nov., 1961, 85, 1141-1144. (From: The Department of Anatomy, University of Toronto, Toronto, Canada.)

The patterns of the trabeculae in the upper end of the femur have been a subject of research for many years. In any bone there are two major groups of trabeculae. The primary trabeculae run parallel to the lines of force transmitted through the bone, and resist static distortion. The secondary trabeculae are oblique to the primary trabeculae, and resist dynamic distortion. In the presence of osteoporosis, since there is a generalized loss of volume of bone matrix, the remaining tissue becomes organized in such a way that the maximum bone tissue is concentrated in the primary trabeculae. This occurs at the expense of the secondary trabeculae which undergo atrophy to the point of disappearance. In the upper end of the femur the degree of osteoporosis can be estimated by this change, and an anteroposterior roentgenogram, of reasonable quality, taken to demonstrate the fracture of the hip, will show the extent of the change in the unbroken femur.

The author examined roentgenographically 30 femora of unknown age and history. In addition, the upper ends were sectioned in the sagittal and coronal planes and also roentgenographed.

A comparison of the appearance of the secondary arciform trabeculae with the primary ventricle trabeculae allows an easy division of the bones into three groups on the basis of their anteroposterior roentgenographic appearance.

Group 1—Equal development of the two rays of trabeculae, which is believed to be the "normal" state.

Group 2—The secondary trabeculae are about half as dense as the primary trabeculae.

Group 3—The secondary trabeculae are scarcely seen on the roentgenogram.

In addition, roentgenograms of the sagittal sections through the neck of the femur show that the cortical thinning is found to the greatest extent in the anterior surface of the neck.

The density of the pattern of trabeculae is important in regard to the strength of bone which would resist the occurrence of a fracture, and is also important in the most advantageous placing of metallic internal fixation should such a fracture occur.—*William C. MacCarty, Jr., M.D.*

PASTREMOLI, A. Importanza e significato di un segno radiologico di periartrite scapolo-omerale: l'eburnizzazione cervico-tuberositaria. (Importance and significance of a radiologic sign in scapulohumeral periarthritis: eburnation of the anatomic neck and of the greater tuberosity of the humerus.) *Radiol. med.*, Sept., 1961, 47, 831-845. (Address: Dott. Alfredo Pastremoli, Via Delle Tofane 14, Bologna, Italy.)

In scapulohumeral periarthritis roentgenologic diagnosis is possible only when there is calcification of the periarticular soft parts. In 60 per cent of the cases the examination may be negative.

The new roentgenologic sign proposed by the author is either a small zone or a marginal line of bone condensation, about 1 or 2 mm. in thickness situated in the external profile of the anatomic neck or in the superior contour of the greater tuberosity of the humerus. This sign represents degenerative osseous changes which have taken place at the site of implantation of the supraspinatus muscle and of the rotator cuff and indicates alterations of the tendinous insertions. It may exist alone or may be associated with other signs, i.e., periarticular calcification and degenerative osteoarthritis.—*Anthony A. Blasi, M.D.*

DELAHAYE, R. P., WEBER, J., and BARRES, J. Le phénomène du vide dans les articulations de l'épaule et de la hanche (à propos de 15 observations). (The vacuum phenomenon in the shoulder and hip joints [based on 15 cases].) *J. de radiol., d'électrol. et de méd. nucléaire*, Oct., 1961, 42, 541-545. (From:

Service Central d'Electroradiologie de l'hôpital du Val-de-Grâce, Paris, France.)

The spontaneous presence of air in joints, called the vacuum phenomenon, is of uncertain etiology. The authors have studied 15 cases, of which 14 were in the shoulder and 1 in the hip. Eleven of these had history of trauma; the others had arthritis or arthralgias.

In the shoulder the characteristic finding is a crescentic shadow 1 to 2 cm. long, slightly wider above and lying in the upper half of the joint. In the hip the shadow is slightly longer and of uniform width. Position of the shadow and its nature as an abnormal finding were confirmed in one of the authors' cases by laminagraphy. In 2 instances the shadows were detected on repeat studies 2 months later.

As the shadow is best seen in the shoulder when the arm is externally rotated, the authors attempted to reproduce it in normal subjects by rotation under traction, but were unable to do so. They believe that the phenomenon may be explained by alterations of the articular surfaces.—*Frank A. Riebel, M.D.*

BURAGGI, G. L., and PEDOJA, G. La brachimetapodia: contributo allo studio delle malformazioni dei metacarpei e dei metatarsi. (Brachymetapody: a contribution to the study of malformations of the metacarpal and metatarsal bones.) *Radiol. med.*, Sept., 1961, 47, 814-830. (Address: Dott. G. Buraggi, Via Machiavelli 40, Milano, Italy.)

In brachymetapody, or brachydactyly, there is a shortening of the digits of the hand and of the toes of the foot which is caused by a diminution in length of the metacarpal or metatarsal bones.

The authors classify this entity etiologically into four groups: (1) hereditary and familial; (2) endocrine and secondary to generalized bone disease; (3) secondary to aseptic necrosis; and (4) essential in which the causative factors are not determined. They present a number of cases: 1 was classified as essential; 3 were hereditary in nature; in a fifth dyschondroplasia and multiple exostoses were observed.—*Anthony A. Blasi, M.D.*

HIRSCH, CARL, and NACHEMSON, ALF. Clinical observations on the spine in ejected pilots. *Acta orthop. scandinav.*, 1961, 31, 90-102. (From: The Orthopaedic Department, University of Gotenburg, Gothenburg, Sweden.)

All 55 pilots who escaped by catapult ejection from 1957 to 1960 were examined physically and had roentgenograms of the thoracolumbar spine including laminagrams.

Fourteen of the 55 (27 per cent) had compression fractures: 5 had only 1 vertebra compressed, 8 had

multiple fractures and 1 had a fracture prior to ejection. The multiple fractures were noted in 1 patient with 7 fractures, 1 with 4, and 4 with 3 fractures each. The most common site was the midthoracic region.

The fractures were discovered by routine examination in 29 of the 32 fractured vertebral bodies and the symptoms were fairly mild; 25 per cent of the injuries consisted of central depression of the superior end plate.

There was no indication that prior disorders, such as spondylolisthesis, or osteochondritis were aggravated by the ejection. Prior back pain in 5 pilots was not aggravated after ejection.

All but one pilot (with associated femoral fracture) returned to active duty. The disability averaged 2 months. Apparently low back pain and sciatica need not be a reason for rejecting a pilot.—*Martha Mottram, M.D.*

EJRUP, B., and HIERTONN, T. Vascular problems in orthopaedic surgery. *Acta orthop. scandinav.*, 1961, 31, 114-129. (From: The Orthopaedic Department of the Karolinska Institutet Norrbackainstitutet, Stockholm, Sweden.)

Several vascular-orthopedic problems are briefly discussed including:

1. Congenital vascular anomalies. Differences in leg length may occur with vascular anomalies. The possibility of interrupting a growth stimulation depends on the extent of the vascular changes and how early treatment is undertaken. Several cases are presented including arteriovenous communication, congenital aplasia of the arteries and hemangiomas.

2. Traumatic arterial lesions. The orthopedist may be confronted with multiple injuries of an extremity including arterial contusion or laceration. Contusions are often accompanied by thrombosis and signs of ischemia; arterial continuity must be immediately re-established.

3. Peripheral vascular emboli are an indication for arteriography so that the amputation level can be as conservative as possible.

4. Arteriosclerosis obliterans. Arteriography is necessary to determine if a vascular reconstruction is possible. Assessment of the circulatory status can be made also by oscillography, fluorescein testing and skin temperature measurement.

In a study of 500 amputees (1951-1957) vascular disease was the basis for amputation in 55 per cent of the cases. The number of high amputations may be reduced by (1) careful assessment of the circulatory status; (2) medical treatment, and edema and infection prophylaxis; (3) individualization of the amputation level; and (4) use of vascular surgery techniques for possible reconstruction.—*Martha Mottram, M.D.*

BLOOD AND LYMPH SYSTEM

BASU, A. K. Occlusive disease of the aorta and its main branches. *Brit. J. Surg.*, Sept., 1961, 49, 148-156. (From: Department of Surgery, Institute of Postgraduate Medical Education and Research, Calcutta 20, India.)

The author discusses previous reports describing occlusive vascular disease of the aorta and believes that previous eponyms such as Takayasu's disease or Martorelli's syndrome are not inclusive of all aspects of the disease. "Pulseless disease" is not a suitable term as many cases have palpable pulses. He suggests the non-committal term "occlusive disease" as being more appropriate, at least until further information regarding the underlying causes would indicate a better term.

He reports 10 cases seen between 1953 and 1960. Most of these patients were young and the presenting symptoms were quite varied depending upon the area of involvement. Various segments of the aorta and its branches were affected. The diagnosis was established by aortography in all cases. In several instances the vascular deficiency could be corrected by means of bypass grafts.

The author suggests the possibility that the underlying cause may be of a rheumatic nature. This is based on some of the clinical features and somewhat on the histologic changes. The findings at surgery and in several autopsies showed thickening of the vascular wall with generalized narrowing of the lumen. There were atheromatous changes and occasionally calcification.—George L. Sackett, Jr., M.D.

GIBSON FERREIRA COSTA, B. Espermato-reno-espleno-portografia; espermatoportografia. (Spermatic-renal-splenic-portography; spermatopography.) *Rev. brasil. de cir.*, Sept., 1961, 42, 147-153. (From: Faculdade de Medicina da Univ. da Bahia, Brazil.)

Percutaneous spleno-portography is now regarded as a routine procedure prior to performing a surgical shunt between the renal and splenic veins. The author has endeavored to find a procedure whereby the results of the shunt could be evaluated. Beginning in 1957, he catheterized the spermatic vein in 16 cadavers, and showed that the polyethylene tube can be advanced to the site of the vascular anastomosis; subsequent instillation of contrast media demonstrated the degree of patency achieved, and to some extent the potential bypass volume. Since 1959 he used the procedure also in 9 live patients, with satisfactory results.

This is a preliminary note and no technical details are offered, but it would seem that the procedure does not require major surgery. Indeed, the author specifies that in females, one would have to catheterize the utero-ovarian vein, and even then it may not yield quite as good an estimate as in male patients.—E. R. N. Grigg, M.D.

GENERAL

DREISINGER, FRANK W., and GENSINI, GOFREDO G. A report on the use of grids for fluoroscopy: image intensifiers and cineradiography. *Radiology*, Oct., 1961, 77, 586-590. (Address: 17325 Euclid Ave., Cleveland 12, Ohio.)

Today manufacturers make radial, parallel, and crisscross grids in at least 7 ratios, with various interspace materials. The authors tested 8 stationary grids for absorption in conventional fluoroscopy, cineradiography, rapid serial radiography and small field fluoroscopy.

Various arrangements of equipment were used, differing in any one series only in the grids employed. "Clean-up" was greater for the grids with higher ratio. The best compromise for inclusion of "clean-up" and low absorption was the Smit 5½:1 grid. The Liebel experimental was the lowest absorbing grid. Its use resulted in the shortest possible exposure times for spot films, rapid serial radiography and cineradiology. Nongrid techniques may be preferred by many radiologists using five inch intensifiers or doing small-field fluoroscopy.—J. C. Moore, M.D.

RADIATION THERAPY

RICHARDS, GEORGE J., JR., and LEWISON, EDWARD F. Inflammatory carcinoma of the breast. *Surg., Gynec. & Obst.*, Dec., 1961, 113, 729-732. (From: The Department of Radiology and Breast Clinic of the Department of Surgery, The Johns Hopkins Hospital, Baltimore, Md.)

Inflammatory carcinoma of the breast comprises about 3 per cent of all cases of carcinoma of the breast. The average age in this series of 19 patients was 43 years, slightly less than the average age of all breast cancer patients. Although it was originally described by Volkmann as occurring in pregnancy and lactation it may occur in adult women of any age. It may be seen in association with any pathologic type of breast carcinoma and may become apparent at any time during the course of the disease. The primary type occurs simultaneously with underlying carcinoma in an otherwise normal breast. The secondary type occurs in a breast already known to harbor carcinoma or following mastectomy, or coincident with the development of a metastatic or second primary tumor in the opposite breast.

Clinically the skin is edematous, brawny and dimpled, producing the typical peau d'orange appearance. The color varies from faint pink to fiery red or dusky purple. The temperature of the skin is frequently increased. The areas of redness spread with a distinct raised periphery. There is a marked tendency to spread to the opposite breast and re-

gional lymph nodes. This appearance should not be confused with the secondary inflammatory reaction of a superficially located carcinoma which has the peau d'orange appearance of inflammatory carcinoma but lacks the border of hyperemic induration diagnostic of true inflammatory cancer. Two of the 19 reported cases were treated initially as breast abscesses and in other series treatment for acute mastitis has been instituted before the true diagnosis became apparent.

The principal pathologic feature was permeation of the subepidermal lymphatic channels by cancer cells. The deeper subcutaneous lymphatics frequently contained cancer cells.

Treatment varied from radical mastectomy without irradiation, pre- and postoperative irradiation, and biopsy plus radiation therapy. There were no 5 year survivals and the average survival was 12 months. Those that have undergone pre- and postoperative irradiation received a tissue dose of 4,000 r in 3-4 weeks utilizing anterior and posterior axillary-supraclavicular fields and tangential chest wall fields. Conservatism in treatment methods is emphasized in view of the poor results obtained by all treatment modalities.—*David Morse, M.D.*

KEEFER, GEORGE P., and VASTINE, JACOB H. Lymphangiosarcoma in the lymphedematous arm after mastectomy. *Radiology*, Nov., 1961, 77, 722-727. (Address: 136 South 16th St., Philadelphia 2, Penna.)

Although few cases of lymphangiosarcoma developing in the lymphedematous arm after mastectomy have been reported, the condition probably is more common than is indicated by the number of recorded cases. Chronic lymphatic obstruction appears to be an overwhelming common factor in all reported cases of lymphangiosarcoma. Lymphedema usually has been present six or more years when the first signs of malignant change become evident. A faint purplish-red, subdermal, macular lesion, having the appearance of a "bruise" or an area of ecchymosis, is the first evidence of the disease. This gradually enlarges, the discoloration increases and induration develops. Satellite lesions appear and become confluent forming bullous or papillomatous tumors. Edematous and hemorrhagic blebs and ulceration occur as the disease progresses.

Some authors have likened the histologic pattern of lymphangiosarcoma to certain phases of Kaposi's sarcoma. Three states of development have been described: (1) edema and degenerative changes of the collagen tissue and fat in the dermis and subcutaneous tissue; (2) proliferation of small vessels in the dermis and subcutaneous tissue; and (3) bizarre vascular channels lined by pleomorphic malignant endothelial cells, frequently containing red corpuscles, infiltrating the adjacent tissue.

No single therapeutic measure has proved satis-

factory in lymphangiosarcoma. In some instances, good immediate clinical regression of the tumor has been achieved with irradiation. Amputation should be considered if a favorable response is not obtained within a relatively short time after irradiation. Chemotherapy may prove effective in the control or possibly in the cure of the disease. The authors report four cases, all with a fatal termination.—*A. W. Sommer, M.D.*

THOENY, ROBERT H., HUNT, ARTHUR B., DOCKERTY, MALCOLM B., and CHILDS, DONALD S., JR. A study of ovarian dysgerminoma with emphasis on the role of radiation therapy. *Surg., Gynec. & Obst.*, Dec., 1961, 113, 692-698. (From: The Sections of Surgical Pathology, Obstetrics and Gynecology, and Therapeutic Radiology, Mayo Clinic, and Mayo Foundation, Rochester, Minn.)

Twenty-seven cases of dysgerminoma of the ovary are discussed with emphasis on the difference in clinical behavior from ovarian tumors in general. The lesion occurred most commonly in young sexually normal women. It first manifested itself by abdominal pain in 45 per cent and by abdominal swelling or mass in 33 per cent of cases; 74 per cent of the patients had an abdominal mass on initial examination. The tumor was unilateral in 93 per cent and spread by direct extension and lymphatic channels to the periaortic, mediastinal and supraclavicular lymph nodes. Hematogenous dissemination was a late manifestation and peritoneal implantation was observed rarely.

Pathologically the tumors resembled the seminoma of the testis and, on the basis of cytologic anaplasia, all were of Grade 4 malignancy.

The recommended treatment is bilateral salpingo-oophorectomy and total hysterectomy. Six of 11 patients, who had unilateral salpingo-oophorectomy because of well encapsulated tumor without spread, had recurrences. Routine postoperative roentgen therapy resulted in higher cure rates than surgical treatment alone.

The treatment fields should include the pelvis and a generous area over the periaortic region extending to the diaphragm. A midplane dose of 3,000 r in 4 to 5 weeks is suggested using orthovoltage or supervoltage therapy. The 5 year survival rate was approximately 60-70 per cent with all known deaths in this series occurring within 1 year. Recurrences usually appeared within 2 years.

Several cases are described in which patients who had pelvic and abdominal lymph node metastases at the original operation had roentgen therapy and are living 10 to 19 years post treatment. Dysgerminoma is radiosensitive and therefore a radiocurable lesion, deserving of an aggressive therapeutic ap-

proach by surgeons and radiotherapists.—*David Morse, M.D.*

ARIAGNO, RICHARD P., and LUTTERBECK, EUGENE F. Combined therapy of intrinsic aural carcinoma. *Quart. Bull. Northwestern Univ. M. School*, Winter, 1961, 35, 285-289. (From: The Departments of Otolaryngology and Radiology, Northwestern University Medical School; Radiation Center, Cook County Hospital; and Chicago Wesley Memorial Hospital, Chicago, Ill.)

The rare malignant tumors of the middle ear and mastoid usually arise in the midst of chronic infection and are far advanced into the temporal bone and facial nerve at the time of diagnosis. Surgical extirpation supplemented by contact and external beam irradiation has controlled the disease for periods of 3 years and 19 months in 2 patients.

Surgical removal of gross disease was followed by contact therapy in each instance. A Philips 50 kv. tube with a contact area of 1.0 cm. diameter, half-value layer 0.5 mm. Al was employed in the operating room with the first patient anesthetized. A dose of 7,000 r was delivered to the tumor base in slightly more than 5 minutes. In the second patient Heyman capsules filled with Co⁶⁰ were inserted into the surgical defect. In 22 hours a dose of 5,000 r was achieved at a distance of 0.5 cm. around the sources. Both patients received additional external orthovoltage treatment via anterior and posterior auricular portals. Doses of 3,200 r and 4,000 r respectively were delivered in a 3 week period.

The advantages of this technique cited by the authors are the operative visual control of the contact implements, the salutary cosmetic result with preservation of the facial nerve and mitigation of the high dose external treatment complication rate, which usually results from the field limiting anatomic characteristics of the temporal bone.—*James J. Snider, M.D.*

TURNER, D. P. B. Vesical haemorrhage after megavoltage irradiation. *Brit. M. J.*, Dec., 1961, 2, 1462-1466. (Address: Consultant Surgeon, Broadgreen, Mill Road, and Newsham General Hospitals, Liverpool, England.)

Four cases of persistent vesical hemorrhage are reported in a series of 17 cases treated with super-voltage irradiation for bladder carcinoma. Between 5,000 and 5,500 rads were given to these 4 cases in a treatment period of approximately 3 weeks. The bleeding developed in areas of residual or recurrent tumor. Inasmuch as bladder neoplasms not subjected to irradiation seldom bleed in this persistent manner, the author postulates that the radiation might have produced some vascular alteration or necrotizing arteriolitis allowing spontaneous rupture

of the vessel with unremitting and severe bleeding.

If conservative measures fail to control the bleeding in 2 to 3 weeks, total cystectomy is urged even if cystoscopy indicates that the tumor has disappeared. Occasionally in some cases transvesical diathermy excision of the bleeding area may stem the hemorrhage. Cystoscopic diathermy and ligation of internal iliac arteries are not effective.—*Bernard Loitman, M.D.*

RADIOISOTOPES

GREEN, M., FISHER, MONICA, MILLER, H., and WILSON, G. M. Blood radiation dose after ¹³¹I therapy of thyrotoxicosis; calculations with reference to leukaemia. *Brit. M. J.*, July, 1961, 2, 210-215. (From: Department of Pharmacology and Therapeutics, University of Sheffield, and the Physics Department, Sheffield National Centre for Radiotherapy, Sheffield, England.)

Radioactive iodine has been used extensively for the treatment of hyperthyroidism due to Graves' disease or toxic nodular goiter in a very large number of cases, perhaps of the order of 80,000 to 100,000. No thyroid neoplasms have as yet been described arising in the glands of adults so treated. The possibility of the development of leukemia as a complication of incidental irradiation of the entire hematopoietic system by circulating radioiodine has lately been considered by a number of investigations. The present authors have summarized the literature from 1956 through 1959 and add one case of their own.

The case in point is that of a woman of 60 with the Graves' disease form of thyrotoxicosis who was treated with 4.9 mc of I¹³¹. Nineteen months later she became rather acutely ill and was found to be suffering from acute monocytic leukemia. She died very shortly thereafter. The authors briefly mention 8 other recorded cases of acute leukemia following radioiodine therapy for thyrotoxicosis, and their own case raises the total to 9. Since the submission of their paper, however, several other cases have been described in the American literature, and the total number of reported cases thus must be of the order of 12 at this time.

The authors estimate the blood-radiation dose from the therapeutic use of I¹³¹ for benign disease by considering that it arises from three sources: (a) the circulating iodide, (b) the circulating protein-bound iodine, and (c) the whole body irradiation resulting from radioiodine stored in the thyroid gland. Formulas are given for the calculation of blood and hematopoietic system dose derived from each of these three compartments and the results are shown graphically for a series of 191 cases. The mean blood dose and its standard error are given as 1.7 ± 0.06 rads/mc. The total bone marrow dose is estimated to be about 80 per cent of the total blood dose. A nomogram is presented from which the blood radiation

dose in rads may be calculated graphically if one knows the amount of I^{131} administered and the 48 hour protein-bound I^{131} level determined in a preliminary tracer test.

Integral doses were calculated and compared with those obtained by Court-Brown and Doll in a series of patients who developed leukemia after roentgen ray treatment for ankylosing spondylitis. The integral doses were substantially smaller for the radioiodine-treated group and the authors suggest that the risk of leukemia development after radioiodine treatment for thyrotoxicosis is therefore small. They also point out that Pochin surveyed a group of 60,000 patients treated by I^{131} for benign disease and found the incidence of leukemia to be no higher than that which might be expected purely by chance. It would appear from examining the distribution of reported leukemias, however, that the incidence of acute leukemia is higher in the radioiodine-treated group, and that it would therefore be profitable for radiologists and others interested in this form of treatment to report all cases of leukemia occurring in this particular group of patients so that intensive critical evaluation of this possible complication of treatment will be possible.—*Frederick J. Bonte, M.D.*

HIRABAYASHI, ROBERT N., and LINDSAY, STUART. Carcinoma of the thyroid gland: a statistical study of 390 patients. *J. Clin. Endocrinol. & Metabol.*, Dec., 1961, 21, 1596-1610. (From: The Department of Pathology, University of California School of Medicine, San Francisco, Calif.)

This analysis of 390 patients with papillary, follicular and anaplastic thyroid carcinoma observed at the University of California between 1920 and 1959 emphasizes an intricate interrelationship between histologic type, pathologic extent of disease, pre-surgical duration of palpable goiter, age and sex of the patient, the type of surgical procedure performed, and survival. Seventy four per cent of these patients had papillary carcinoma, while 5 per cent of the tumors were anaplastic.

At the time of initial surgery both thyroid lobes were involved in 19 per cent. Carcinoma was confined to the gland in slightly more than 50 per cent of the patients. Local recurrence was observed in 13 per cent (40 of 315) of patients in whom initial operation was considered to have eradicated the primary lesion. A significantly lower local recurrence rate resulted in those patients undergoing total thyroidectomy compared with those treated by unilateral subtotal lobectomy. Two of 96 patients treated with total thyroidectomy experienced recurrence locally, while 10 of 34 patients in the subtotal lobectomy series developed subsequent local cancer. The majority of local recurrences were on the same side as the original tumor.

Regional lymph node metastases appeared in 42 per cent of all cases, and these lymph nodes became involved in 33 per cent of the patients within 2 months after initial surgery. Distant metastases occurred in 16 per cent of all patients and in 6 per cent within 2 months after the initial surgical procedure. No significant relationship was shown between the presence of regional lymph node metastases and distant involvement. This suggested to the authors that the primary neoplasm, rather than the involved lymph nodes, was the source of the distant lesions. This concept was reinforced by the finding that nearly half of the patients with distant metastases did not have cancer within the regional lymph nodes.

Carcinoma of the thyroid gland was the cause of death in 19 per cent of all patients. It accounted for 76 per cent of the deaths in patients with anaplastic thyroid cancer. Thirty three per cent of those with follicular type lesions succumbed to their disease, while only 11 per cent of the papillary tumors were lethal. This study of the natural history of thyroid carcinoma suggests that more radical surgery performed earlier should result in lowered mortality rates.—*James J. Snider, M.D.*

WALDMANN, THOMAS A. Gastrointestinal protein loss demonstrated by ^{51}Cr -labelled albumin. *Lancet*, July, 1961, 2, 121-123. (From: The Metabolism Service, National Cancer Institute, Bethesda, Md.)

Loss of proteins into the gastrointestinal tract has been shown to be a major factor in the hypoproteinemia associated with an interesting variety of diseases including regional enteritis, ulcerative colitis, giant hypertrophy of the gastric mucosa, sprue, gastric neoplasms, constrictive pericarditis and idiopathic hypercatabolic hypoproteinemia. Various tests have been applied to the matter of estimating the amount of protein loss including nitrogen-balance techniques, immunochemical analysis of the gastrointestinal secretions, and the excretion of I^{131} human serum albumin in the stool or in the gastrointestinal secretions. A radioisotope test using the I^{131} -labelled macromolecule polyvinylpyrrolidone (P.V.P.) is also mentioned, but it should be pointed out that synthesis of this compound is exceedingly difficult, and the test is not as yet as reliable as it may some day be.

It has been shown that chromium⁵¹ chloride is poorly absorbed from the gastrointestinal tract and that Cr^{51} -labelled red blood cells have been used to determine the site and amount of gastrointestinal blood loss. It has also been shown that human serum albumin may be labelled with radioactive chromium chloride.

The author prepared two different forms of Cr^{51} -labelled albumin, one passed through Dowex-50 resin, and another with MB-1 amberlite resin.

Thirty to fifty μc of either of the Cr^{51} -labelled

preparations were given intravenously to each subject and for the next 96 hours the stools were collected as a single lot in a metal can. Urine was collected during this 4 day period in 24 hour lots. Stool specimens were adjusted to standard weight with water and homogenized. Urine and fecal specimens were assayed for radioactivity with appropriate standards on a single channel gamma-ray spectrometer. The results are expressed as a percentage of the administered radioactivity which appears in the 4 day collection of urine and stools. The author further showed, by administering some of the test material by mouth, that virtually all of an orally given tracer dose was recovered in the stool. No radioactivity was detectable in urine. Fifteen controls and 8 patients with gastrointestinal protein loss were studied. The patients known to have bowel protein loss excreted from 4 to 21 per cent of the intravenously administered Cr^{51} in the 96 hour fecal collection. The greatest 4 day fecal excretion by the controls was 0.63 per cent. There is reason to believe that urine excretion levels may become useful as well.

The Cr^{51} -labelled serum albumin test appears to be an interesting new method to demonstrate loss of protein into the gastrointestinal tract. In one instance, using external counting methods, it was also used to determine the site of gastrointestinal protein loss.—*Frederick J. Bonte, M.D.*

JOPLIN, G. F., FRASER, RUSSELL, STEINER, R., LAWS, J., and JONES, ELIZABETH. Partial pituitary ablation by needle implantation of Gold-198 seeds for acromegaly and Cushing's disease. *Lancet*, Dec., 1961, 2, 1277-1280. (From: The Departments of Medicine, Radiodiagnosis, and Physics of the Postgraduate Medical School, Ducane Rd., London, W.12, England).

Pituitary overactivity causing acromegaly or Cushing's disease can be treated by one of several methods: (1) external radiation techniques, (2) pituitary surgery (or adrenal surgery for Cushing's disease also), or (3) radioisotope needle implants. In external radiation therapy an upper limit of 4,000 rads per course and 8,000 rads total must be set to minimize damage to the adjacent optic and oculomotor nerves which also receive the full dose of radiation applied to the gland. In "successful" pituitary surgery hyperfunction is usually followed by hypofunction, and often removal of the gland is incomplete; moreover, vital adjacent structures are exposed to damage.

Radioisotope techniques have been used to destroy the gland employing needle implantation of an appropriate isotope (Y^{90} , Rn , Au^{198}). The goal has been to deliver an effective radiation dose sufficient to arrest the disease without impairing normal pituitary function, and without damaging the optic nerve. Au^{198} , a medium gamma emitter, was con-

sidered most suitable for such partial pituitary ablation providing a central necrotizing dose of 100,000 rads with a rapid fall-off to less than 4,000 rads to the optic nerves.

The results of Au^{198} seed implants in 18 acromegalias showed symptomatic relief in all cases with some decrease in their signs of acromegaly; and results in 6 cases of Cushing's disease showed striking remission. Further studies are planned modifying the implant technique toward higher dosage in acromegalias by a combination of Au^{198} and Y^{90} .—*Bernard Loitman, M.D.*

BAUER, GÖRAN C. H., and SCOCCIANI, PAOLO. Uptake of Sr^{85} in non-malignant vertebral lesions in man. *Acta orthop. scandinav.*, 1961, 31, 135-145. (From: The Research Laboratories at the Orthopaedic Clinic Malmö, University of Lund, Sweden, and the Orthopaedic Clinic of University of Florence, Italy.)

After the intravenous injection of bone-seeking tracers, high concentrations will be found in areas where bone formation is active. By this method it is possible to locate areas of active bone metabolism during normal growth or pathologically in fracture, tumor or infection.

This article records the results of external counting over the spine following administration of Sr^{85} to normal patients and those with nonmalignant vertebral lesions. They were given carrier-free Sr^{85} intravenously not exceeding 1 $\mu\text{c}/\text{kg}$. body weight. The optimum time for external counting was determined to be day 14. Counts were made over the posterior spinous processes from S_1 to the mid thoracic region and graphs constructed.

Seven individuals had no spinal disease and their curves were used as a basis of comparison for evaluation of spinal activity in patients with vertebral lesions. The variation in the uptake in normal patients is so slight that a basic activity pattern can be constructed; the shape of this pattern is influenced by the type of detection apparatus in use. A deviation of more than double the standard deviation of the normal mean was used as a criterion of abnormal activity and suggests a pathologic process in the spine. However, a large kidney stone caused a rise in the counting rate in one patient and slow bowel movements an increase in another.

In 8 out of 10 spinal fractures (duration not stated) there was increased activity over the fractured vertebrae and adjacent vertebrae. Two fractures gave normal curves.

In 2 out of 3 cases of tuberculous spondylitis there was increased activity.

Activity peaks were also recorded after removal of a herniated disc in "non-specific discitis," spondylolysis and in one out of 2 cases of spondylarthrosis deformans.—*Martha Mottram, M.D.*

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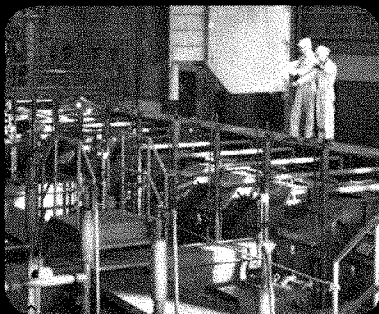


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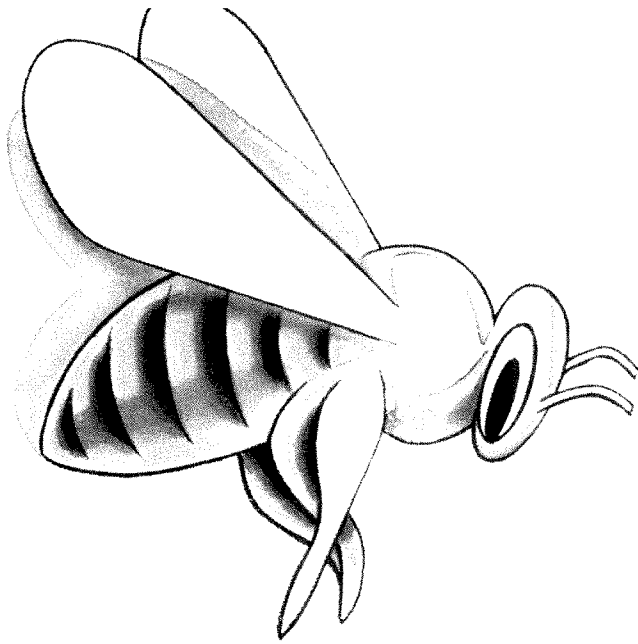
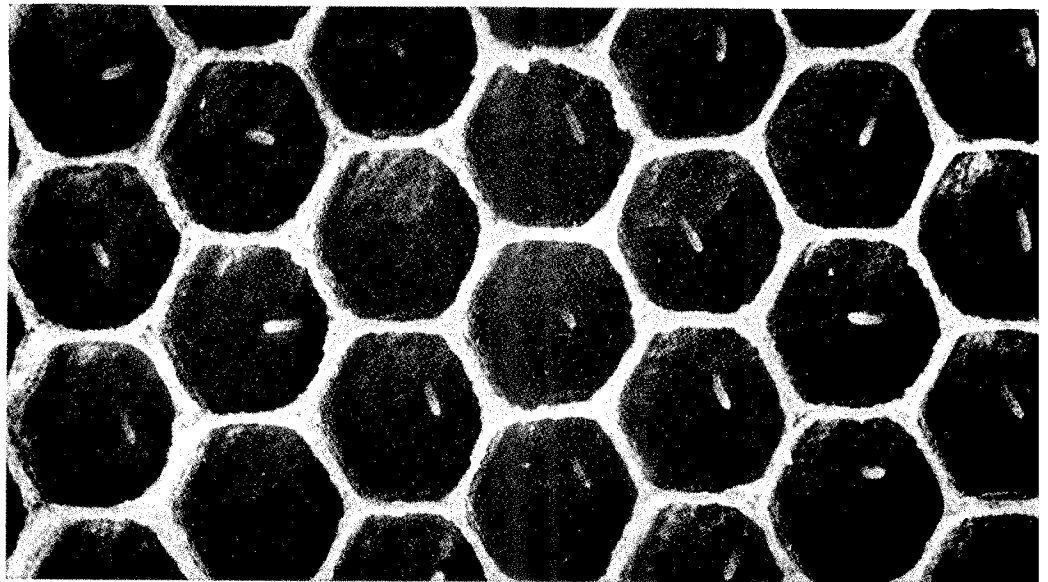


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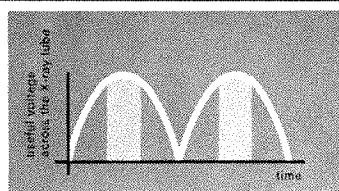
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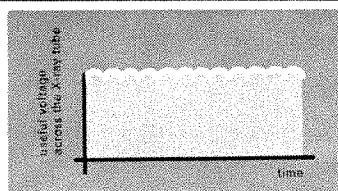
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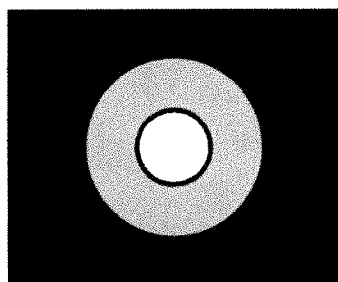
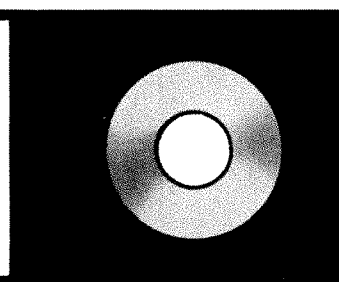


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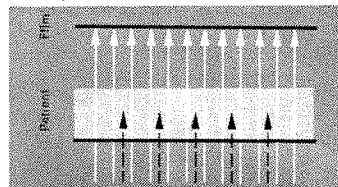
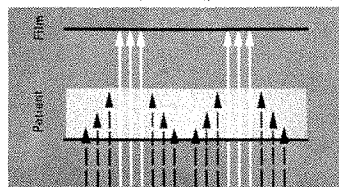
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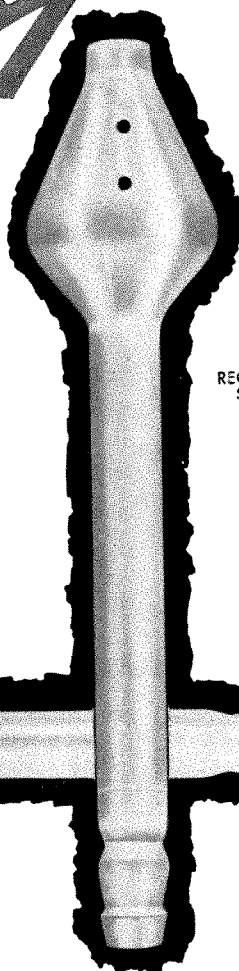
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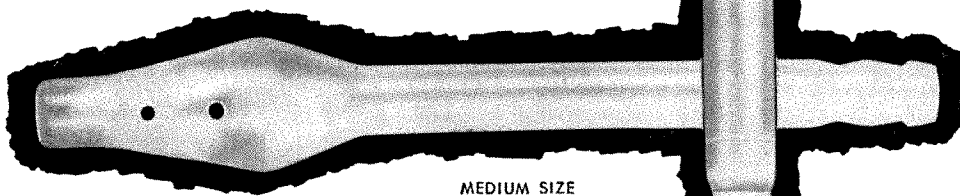
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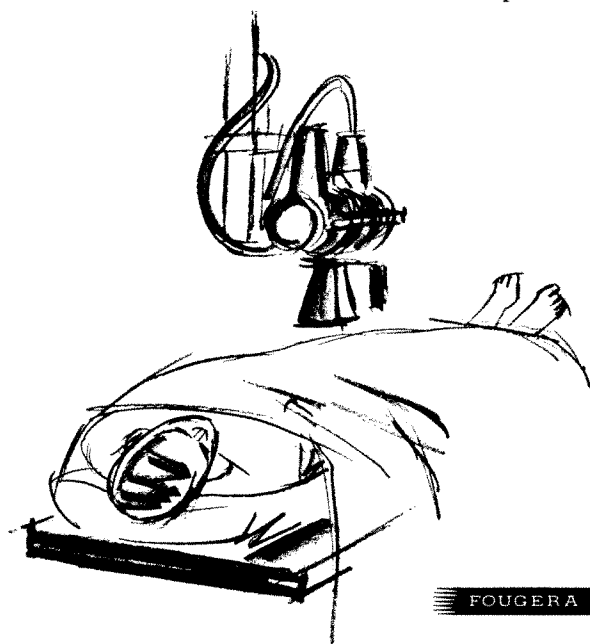
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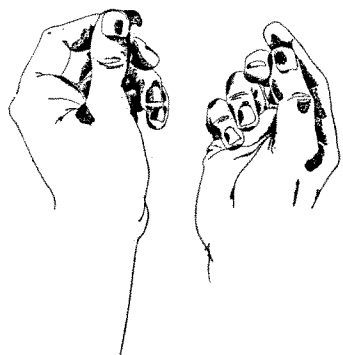
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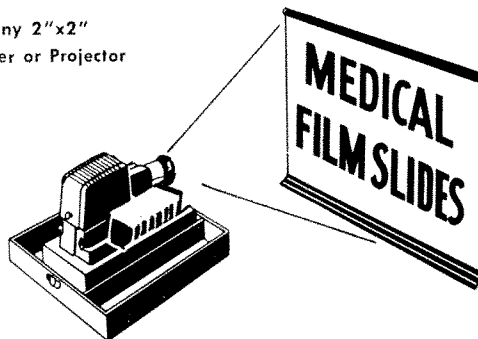


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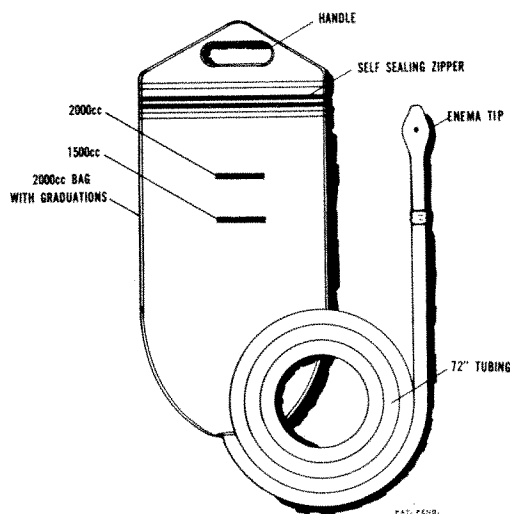
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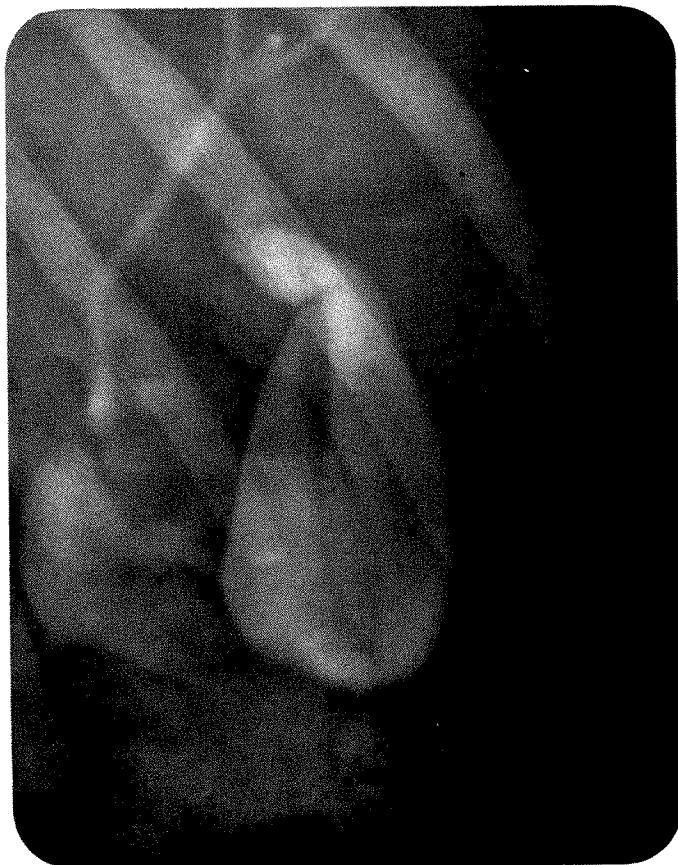
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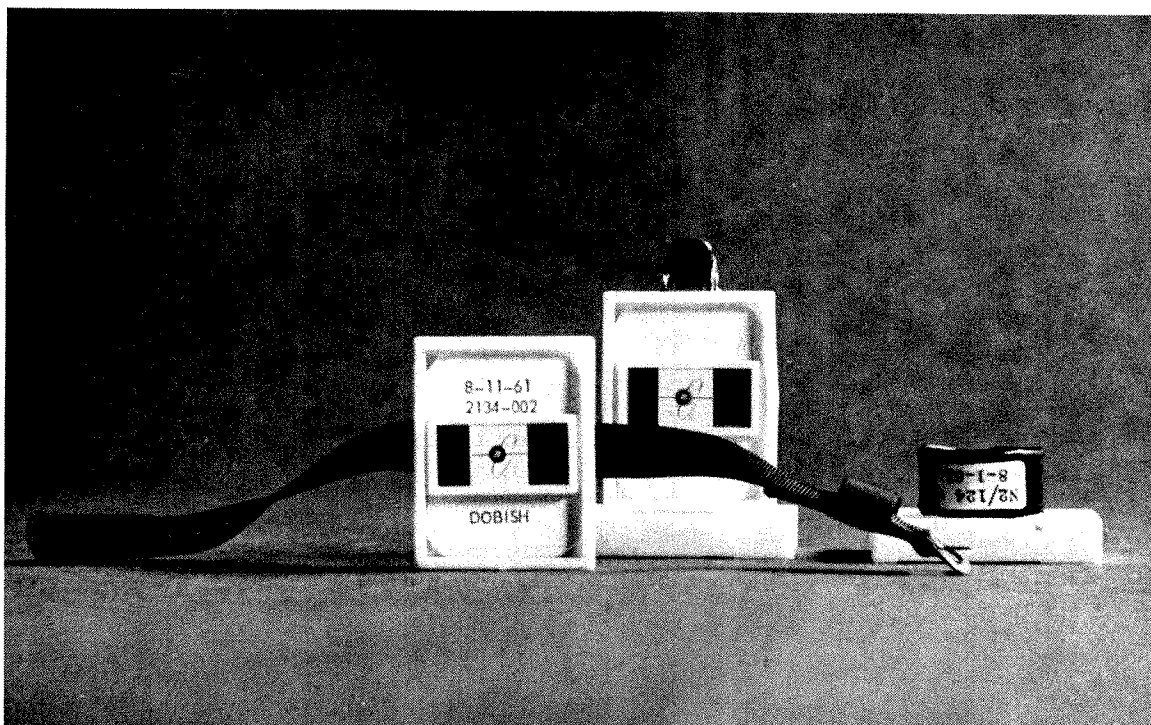
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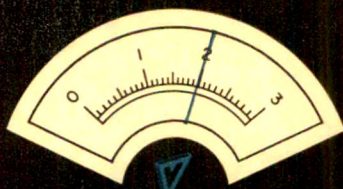
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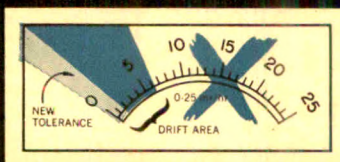
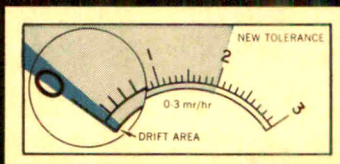
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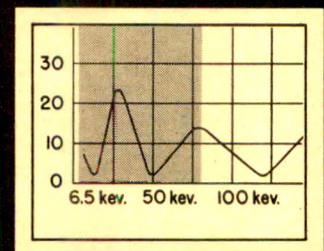
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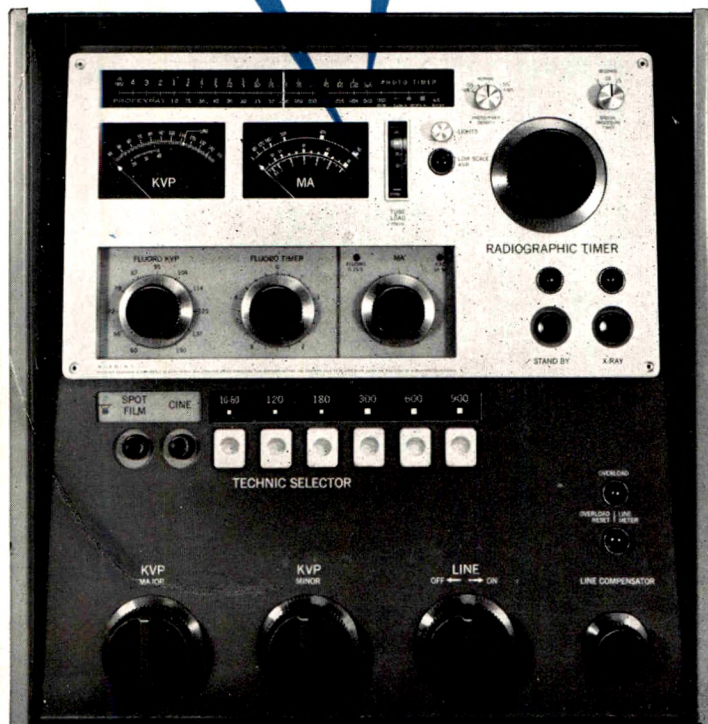
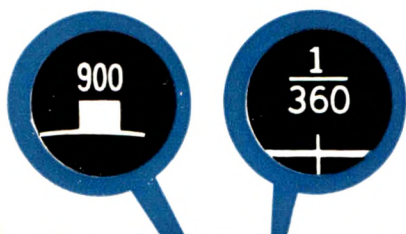
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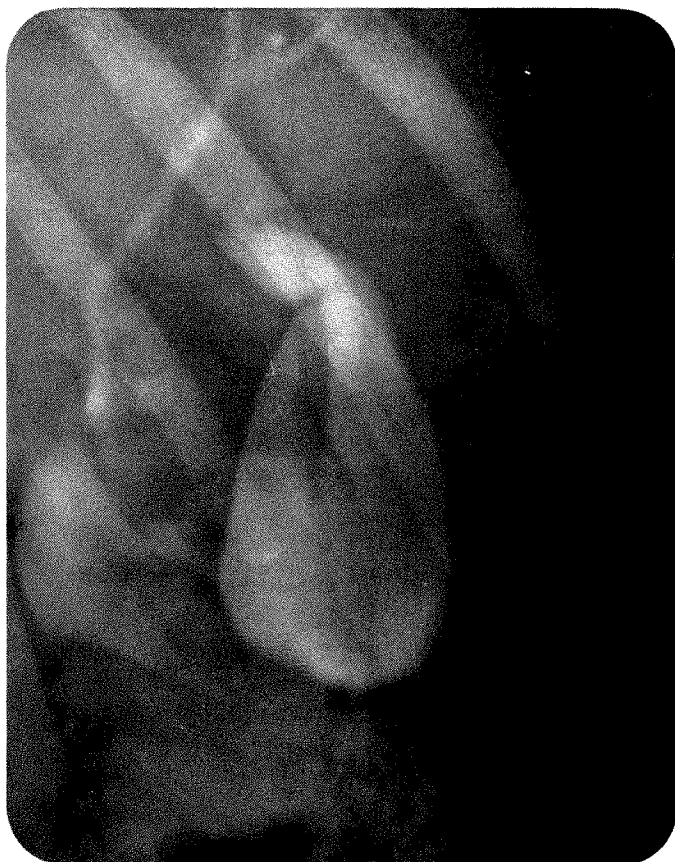
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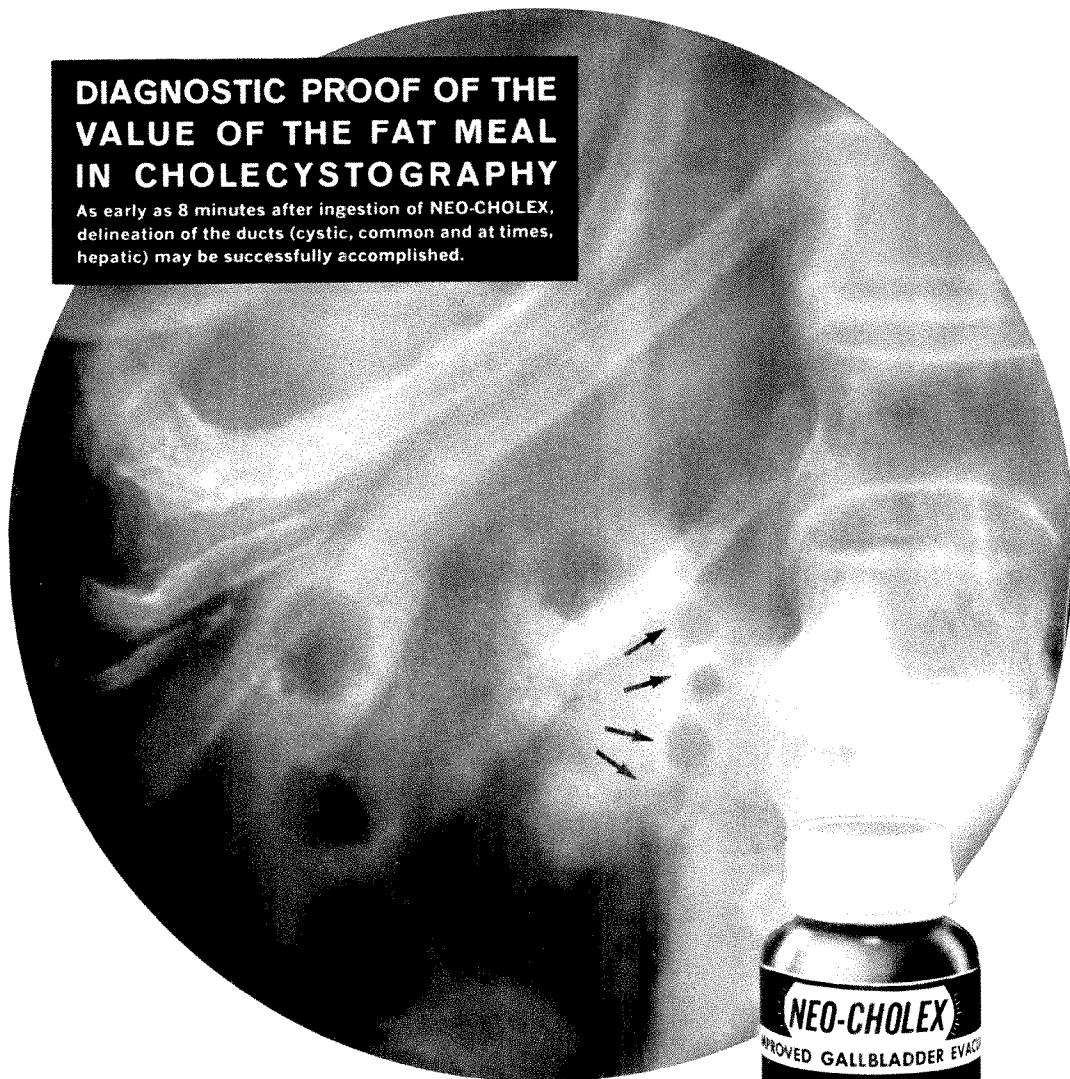


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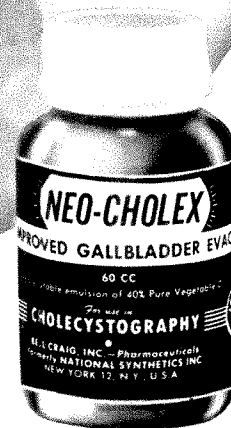
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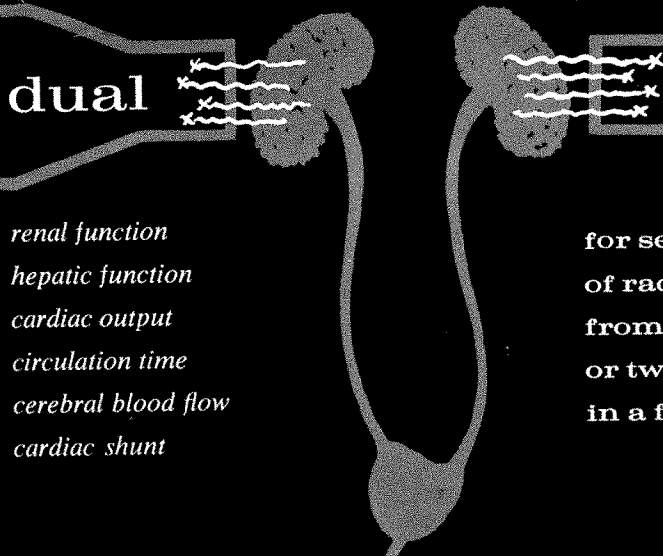
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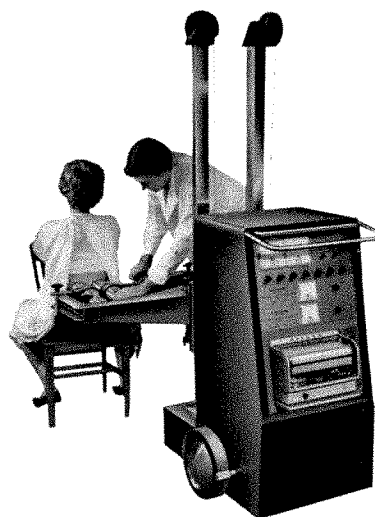
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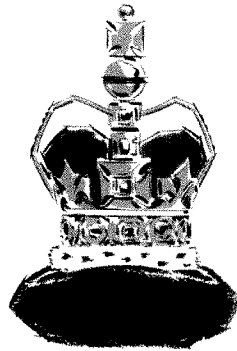
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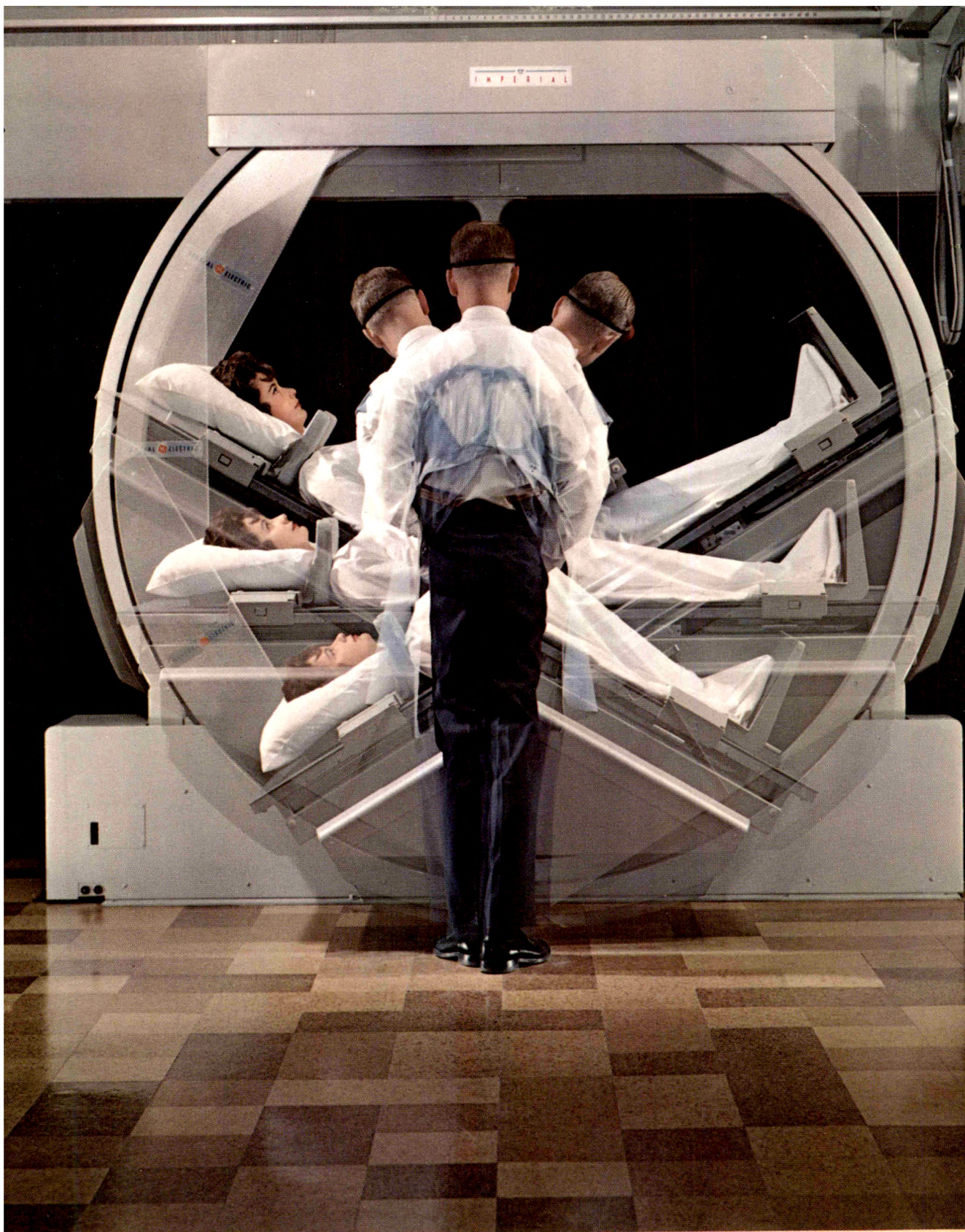
In radiology, as in every professional field, the man who makes heavy demands on himself is the man most likely to make a noteworthy contribution to his field.

It is for this man, this radiologist, that the Imperial II was designed. With this superb diagnostic unit, General Electric offers the most demanding radiologist complete command. Every facility, every procedure, centers — concentrically, geometrically — around the radiologist. Balance, counterbalance, power, control . . . the Imperial responds faithfully, swiftly, effortlessly, to the fingertip touch.

There are facts to support these claims. Some of them will be covered on the following pages; other details are easy to obtain. But you will want to experience, first-hand, the feel of an Imperial II in action. Your General Electric x-ray representative can make arrangements for you to see and try a unit in your area. Or you can secure complete descriptive literature from X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin. Dept. A-61.

Progress Is Our Most Important Product

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THE RADIOLOGIST IS IN COMPLETE COMMAND

. . . even during difficult procedures. An Imperial II diagnostic x-ray installation is oriented to the radiologist. This stop-motion color photo provides a graphic example: with ring-mounted pivoting, screen-to-eye relationship remains practically constant and centered . . . spot-film device neither advances nor recedes as table is tilted.

LONGITUDINAL TABLE MOVEMENT

. . . puts extra facility at your fingertips. Table-top movement — up to 30" at either end — gives you the extension you need in angiographic and other procedures . . . even such conveniences as placing the patient and the spot film device at precisely the right level for you in vertical fluoroscopy.



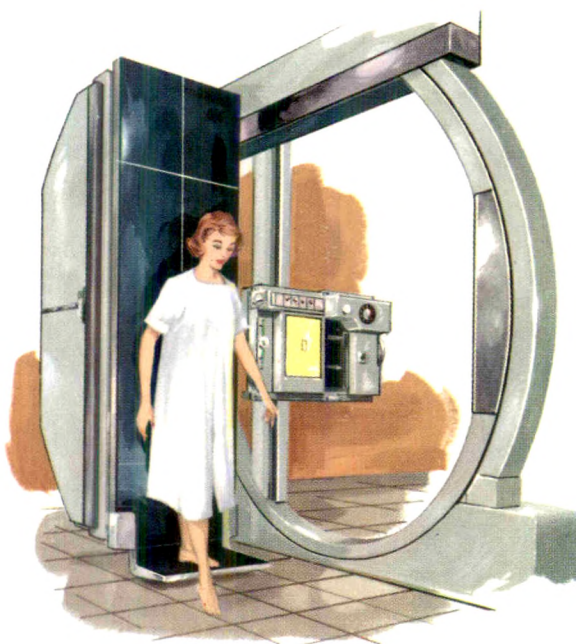
GENERAL ELECTRIC IMPERIAL II

completely uncompromising facilities...



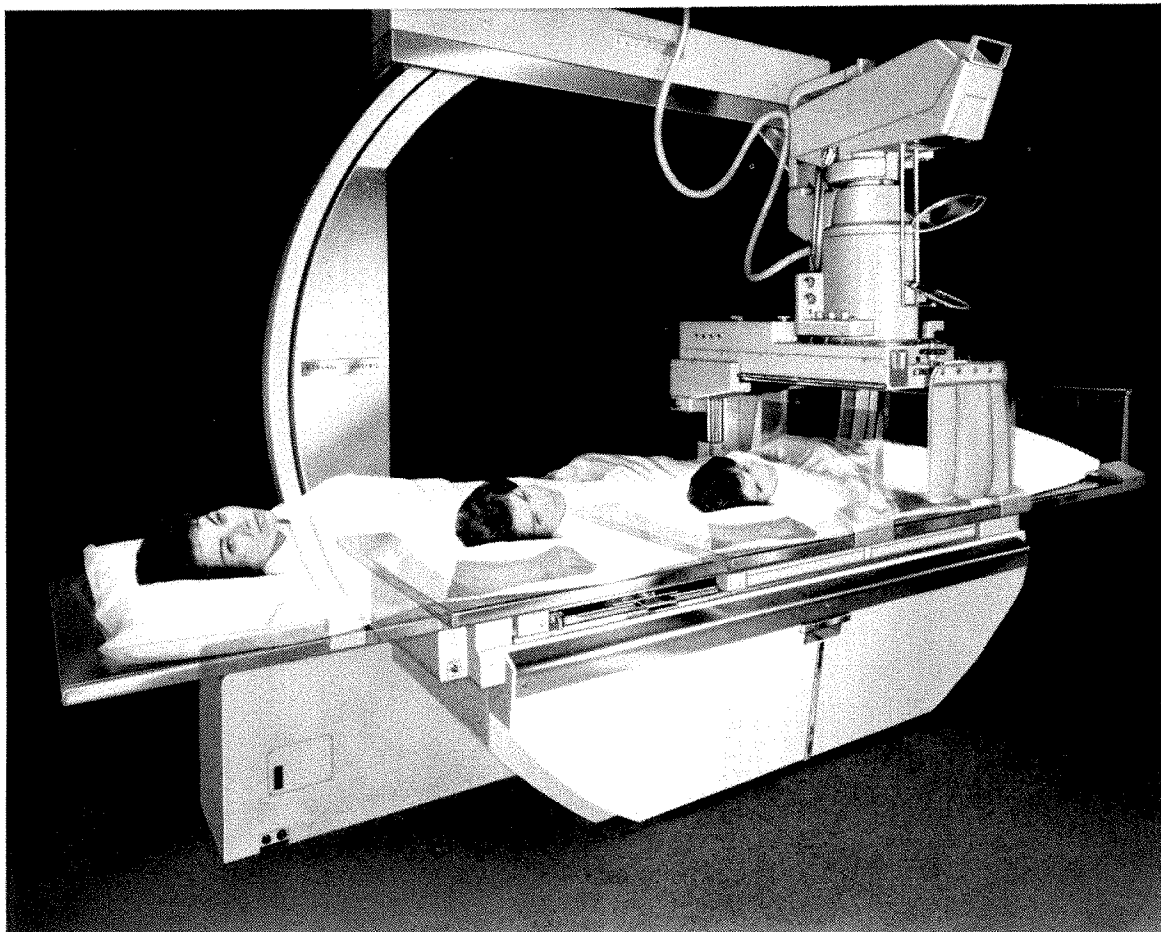
TOE-TOUCH CONTROL

. . . permits you to move patient and table laterally — without hands, without effort — without disturbing the position of the screen. Superbly balanced lateral shift is the reason for this handling ease . . . another almost-automatic way Imperial responds to your every touch.



SLIDE-BACK PARKING

. . . of the spot-film unit means, of course, total unobstructed access to the table for both patient and technician. Yet it's immediately at hand when wanted, with every control feature ingeniously arranged for the radiologist's convenience; table tilt, locks, shutters, sequencing, phototiming density, fluorotimer.



...plus the glide-top that extends itself not the radiologist

No need to extend yourself or your patient with the Imperial II. General Electric's exclusive power-driven glide-top extends 30 inches beyond each end of the table. Travel is smooth and swift at approximately one inch per second. Makes possible many improved methods of handling patients without tugging or pushing.

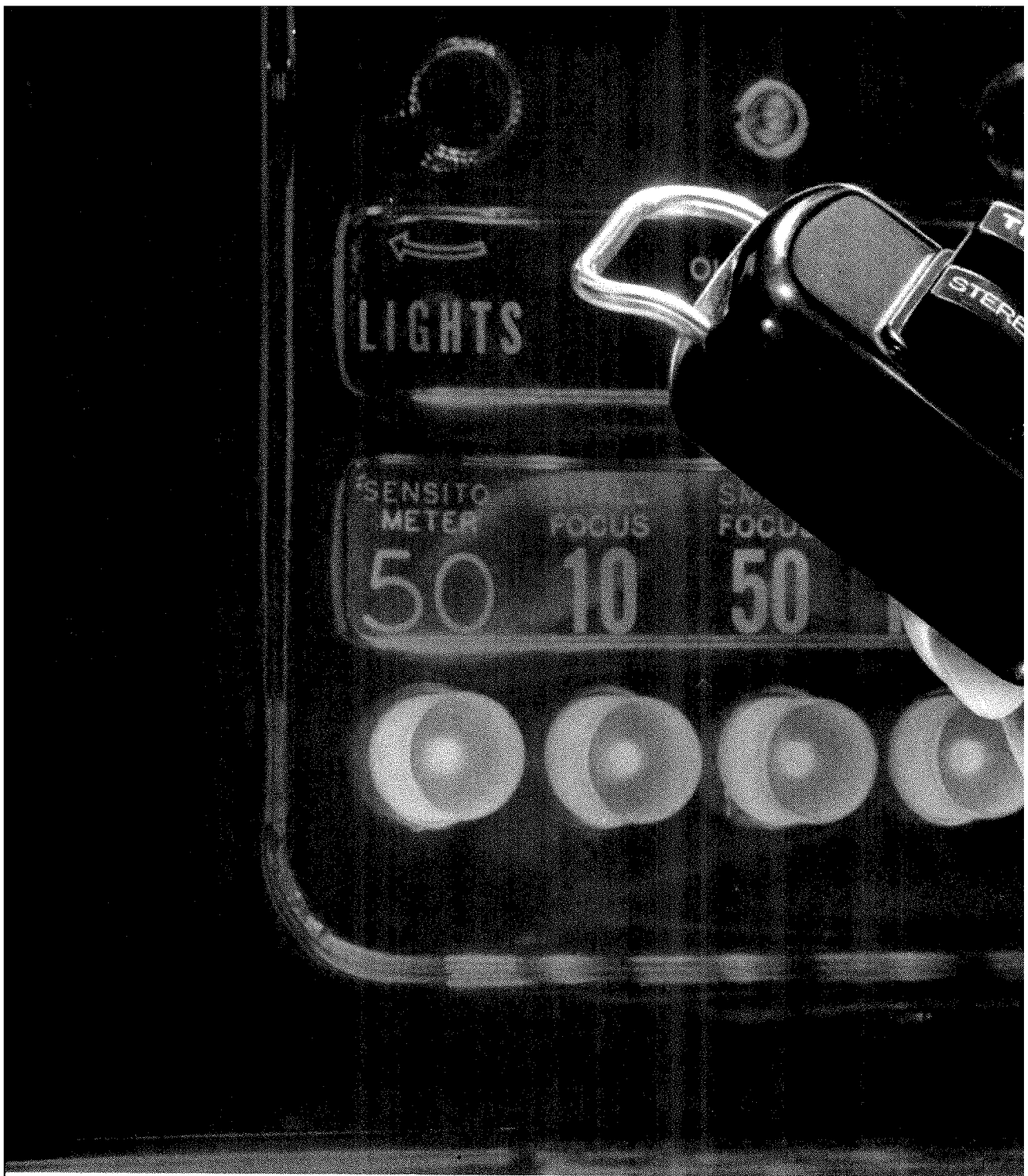
The glide-top adds another convenience to myelography. In combination with the table's unique pivot point it lets you glide the patient into your center of activity—even in exami-

nations of the cervical spine. Angiographic procedures, cerebral examinations, all routine radiography and fluoroscopy, even patient transfers, are easier and more comfortable with the Imperial II glide-top.

For more detailed information on how power-driven glide-top speeds your work, contact your General Electric x-ray representative or write directly to X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin. When writing, please ask specifically for Pub. A-61.

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DISTINCTLY BETTER
VISUALIZATION
DUE TO
HIGH / RAPID
ABSORPTION

The degree of visualization you may expect from an oral diagnostic agent is directly related to its absorption index, and to its selective elimination in the bile by the liver.

An ingested dose of ORABILEX is maximally and rapidly absorbed from the small intestine. Peak blood levels are attained in 1 to 2 hours, as shown by radioisotope studies.^{1,2} Thus, ORABILEX delivers more opacifying iodine to the gallbladder and ducts for distinctly better visualization with minimal intestinal residue.³⁻⁸

ORABILEX provides a more certain diagnosis with less toxicity and fewer side effects.

1. Lasser, E. C., et al: J. Nuclear Med. 2: 79 (April) 1960. 2. Sachs, M.: Personal communication. 3. Whitehouse, W. M., and Fink, J. E., Jr.: Univ. Michigan Med. Bull. 25: 238 (July) 1959. 4. Morgan, L. A., and Parks, R. E.: Radiology 74: 436-441, 1960. 5. O'Laco, J. P., and Wilcox, W. A.: Wisconsin Med. J., 59: 249 (April) 1960. 6. Reeves, R. J.: Am. J. Roentgenol., Rad. Ther. and Nuclear Med., 83: 843 (May) 1960. 7. Farrell, T. E., and Weldon, W. V.: Southern Med. J., 54: 54 (Jan.) 1961. 8. Tatelman, M., and Steel, W. B.: J. Michigan State Med. Soc., 60: 357 (March) 1961.

ORABILEX*

THE CONTRAST MEDIUM OF CHOICE bunamiodyl sodium



* T. M. A DEVELOPMENT OF GUERBET LABORATOIRES

DUE TO HIGH/RAPID ABSORPTION

Fewer repeats... because the reliability of ORABILEX as a diagnostic medium is such that non-visualization usually indicates the presence of hepatic or biliary disease (unless disorders of the small intestine interfere with absorption). Fewer repeats mean greater economy.

DUE TO HIGH/RAPID ABSORPTION

No need for double-triple dosage... because a single 4.5 Gm. (6 capsule) dose of ORABILEX provides more opacifying material for distinctly better visualization. Should non-visualization occur and the physician wish to secure his findings, one additional 4.5 Gm. dose may be given for re-examination the following day.

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Contraindications: Similar to other contrast media of this class, Orabilex is contraindicated in the presence of renal insufficiency.

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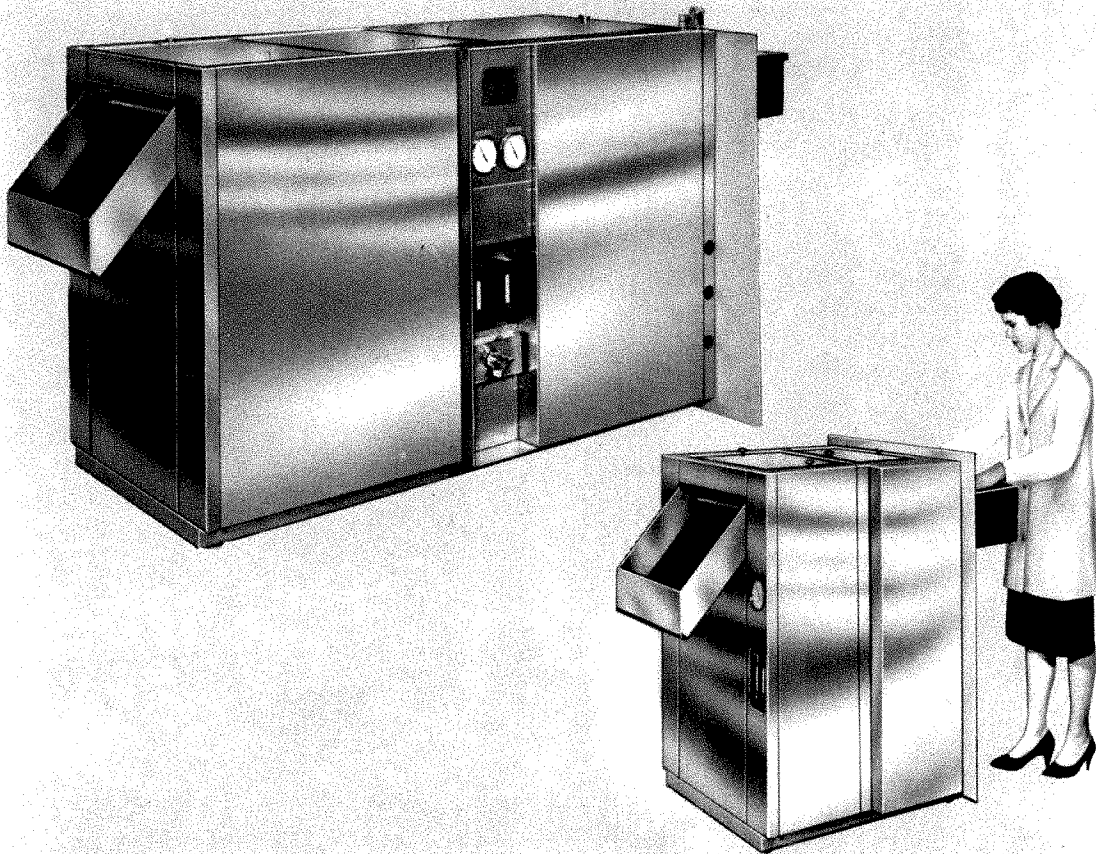
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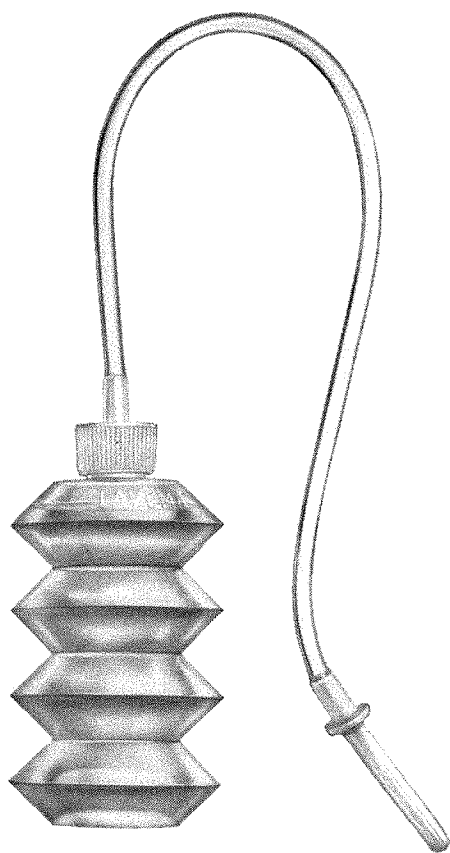
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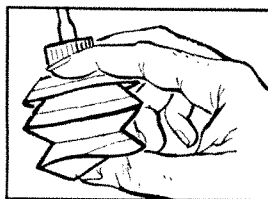
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The new Lavema Compound Disposable Enema Kit makes costly, time-consuming preparation and "clean-up" unnecessary. The accordion-fold plastic squeeze bottle, 15-inch tube and pre-lubricated rectal tip simplify administration by the attendant or by the patient himself. Each Lavema enema unit contains 20 mg. of Lavema (cathartic) and 135 mg. of Superinone[®] (wetting agent and fecal softener).

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Indications: Cleansing prior to proctosigmoidoscopy or operations on the lower bowel... fecal impaction...removal of barium...failure to evacuate after operation.

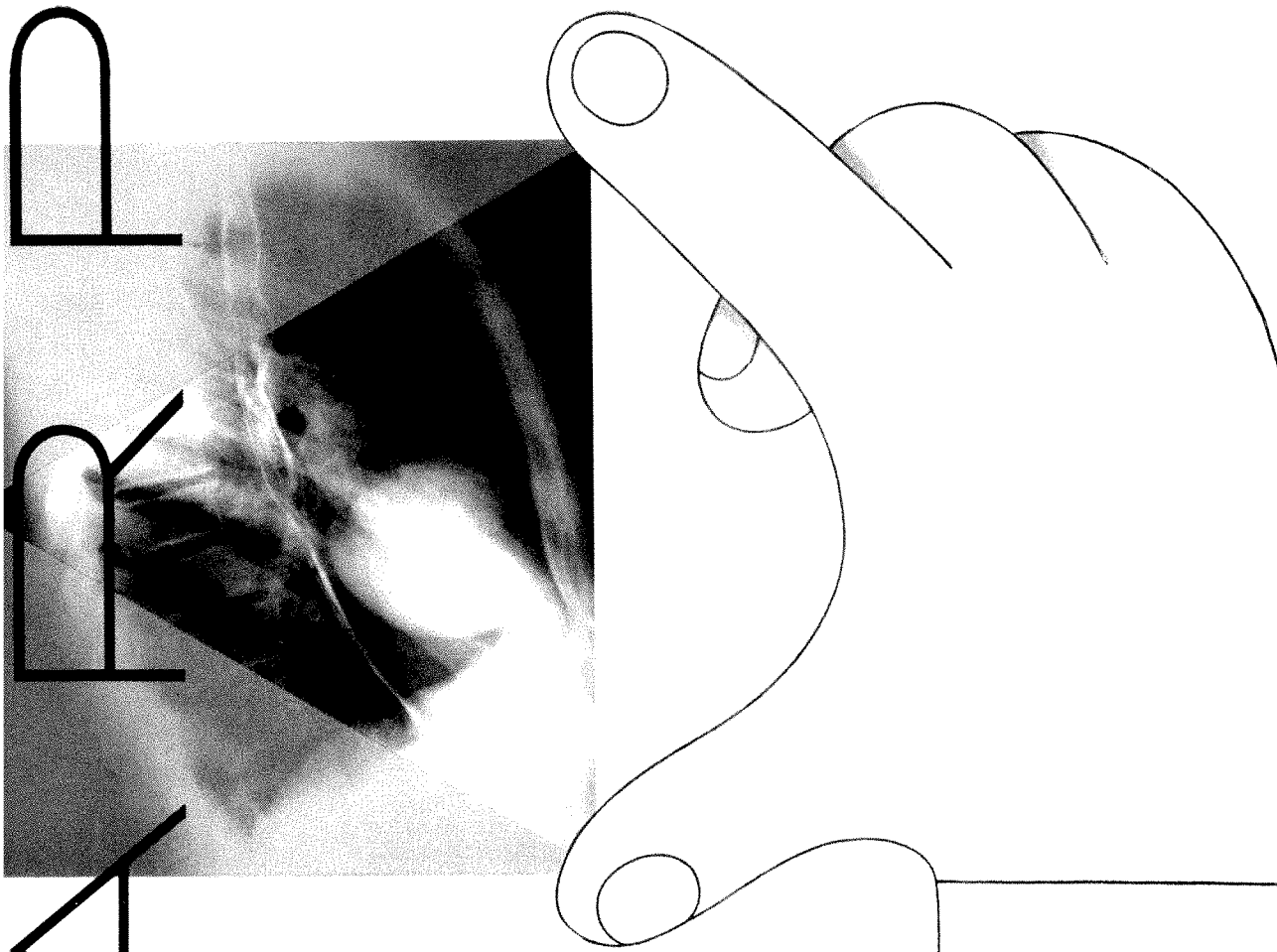
Contraindications and side effects: The usual contraindications to the use of enemas should be observed. Reactions have been infrequent (about 5 per cent of patients) and usually mild. In an occasional patient, cramps, a continued urge to evacuate, sweating, weakness, nausea, pallor or dizziness may occur.

Composition: Each 180 ml. of solution in one enema kit contains 20 mg. of Lavema (brand of oxyphenisatin), 135 mg. of Superinone (brand of tyloxapol) and propylene glycol 5 per cent in water. Available on prescription only.

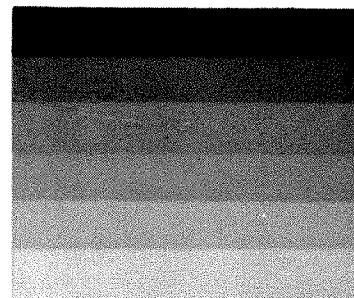
Before prescribing be sure to consult Winthrop's literature for additional information about dosage, possible side effects and contraindications.

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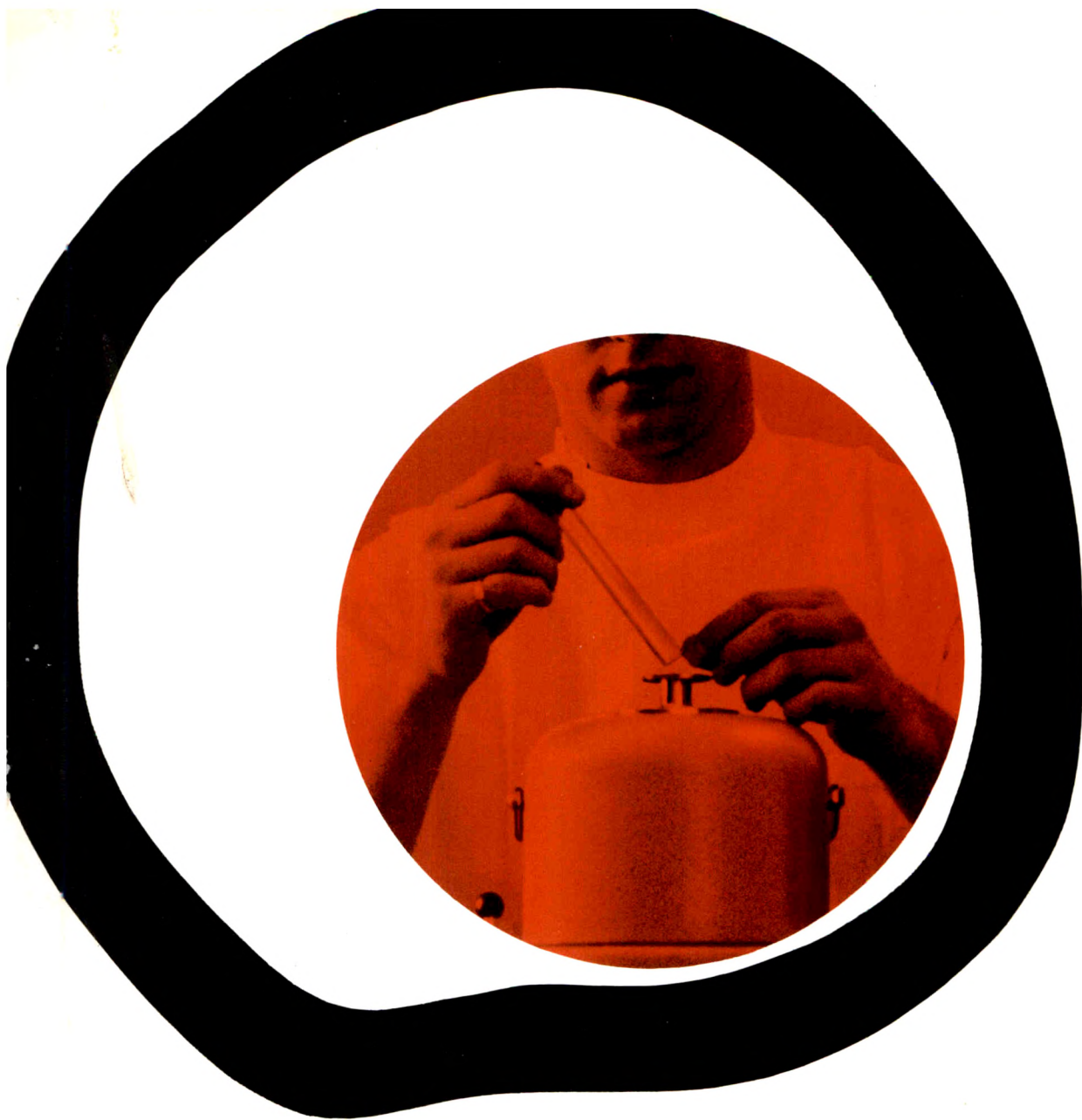


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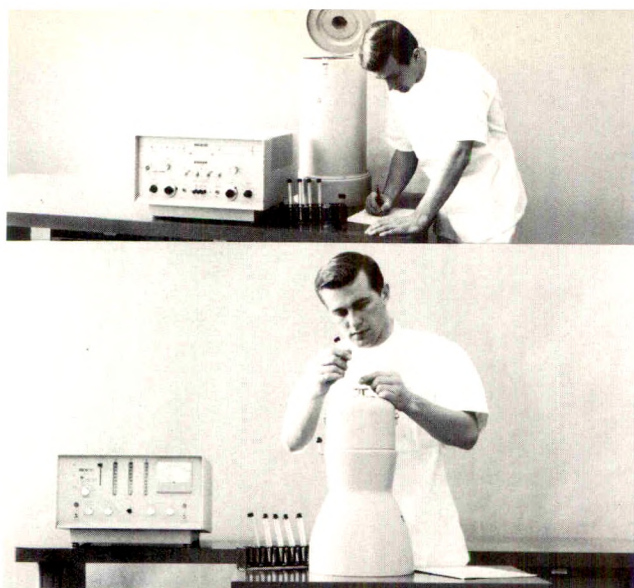
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**MEASUREMENT OF RED CELL MASS AND
RED CELL SURVIVAL WITH RADIOCHROMIUM**





MEASUREMENT OF RED CELL MASS WITH RADIOCHROMIUM

When viable red cells are incubated in a test tube with Cr-51 labelled sodium chromate of high specific activity in a Strumia solution (disodium citrate monohydrate 2.55 grams, citric acid 0.80 grams, dextrose 1.20 grams in 100 ml. of solution) a high percentage of the cells bind the Cr-51. At room temperature 90% of the radiochromium can be bound in 30 minutes. The unbound chromate is reduced to trivalent chromium by ascorbic acid, which does not bind to red cells but is loosely bound to the plasma proteins.

A measured sample of the labelled red cells is reinjected into the patient and another aliquot is used for a standard. In the latter the plasma is removed and the cells are washed with isotonic saline to remove unbound chromium and a dilution is prepared for counting. At 20 and 30 minutes blood samples are drawn and the cells from a measured volume of blood separated and washed with saline. The activities in the standard and samples are measured in the well scintillation detector.

TYPICAL PROCEDURE

1. Draw 20 ml. of the patient's blood and discharge carefully into a sterile siliconed bottle containing 10 ml. of Strumia solution, mix and add 25 microcuries of sodium radiochromate.

Nuclear-Chicago offers a wide variety of scalars, gamma-ray spectrometers, and well scintillation detectors for measurement of gamma-radiation in red cell mass and red cell survival studies. The DS-303 Well Detector with the 132B Clinical Spectrometer is the most versatile and efficient system. It offers the clinician a large three-inch diameter crystal with a well that accommodates sample volumes up to 20 ml. The 132B combines a scaler, pulse height analyzer, and computing circuit in one compact chassis.

The DS-202 Well Scintillation Detector with the 181B Decade Scaler is a low cost versatile system for in-vitro diagnostic studies. Samples in standard 13 mm diameter test tubes can be counted in the well of the two-inch diameter crystal.

2. Incubate 30 minutes at room temperature. Add by sterile syringe 100 mg. ascorbic acid in 1 ml. of solution (sterile and suitable for parenteral administration), mix and allow to incubate 5 minutes.
3. Mix blood well in bottle and withdraw 20 ml. into a sterile syringe. Weigh syringe rapidly on triple beam balance to nearest 0.01 gram.
4. Inject labelled blood through needle placed in vein with another syringe. Do not permit blood from the vein to flow back into syringe containing labelled blood.
5. Reweigh empty syringe to nearest 0.01 gram to determine weight of blood injected.
6. Draw 10 ml. blood samples from opposite arm at 20 and 30 minutes and discharge carefully into blood bottles containing anti-coagulant. Determine hematocrits on samples of blood.
7. Preparation of standard:
 - a. Mix sample of labelled blood well and add approximately 5 ml. to each of two weighed centrifuge tubes.
 - b. Reweigh tubes to determine amount of blood in each sample.
 - c. Centrifuge 10 minutes at 2,000 rpm and carefully pour off plasma. Do not lose red cells.

- d. Add 10 ml. of 0.9% sodium chloride to tubes and *gently* resuspend cells.
- e. Centrifuge 10 minutes at 2,000 rpm and carefully pour off supernatant.
- f. Repeat (d) and (e).
- g. Transfer washed cells to 100 ml. volumetric flask with water. The cells will lyse during procedure.
- h. Mix well and pipette 3 ml. samples into glass tubes and count in well scintillation detector.

Preparation of timed samples:

- a. Mix blood samples well and pipette 5 ml. into centrifuge tube which will fit into well scintillation detector.
- b. Carry out procedures (c) and (d) above.
- c. Count red cells in well scintillation detector.

Calculations:

$$\frac{\text{Total Counts Administered} = (\text{Wt. of blood injected}) (100)}{(\text{Wt. of std. blood}) \quad 3} (\text{std. cpm} - \text{bkg.})$$

$$\frac{\text{Red blood cell cpm/ml} = \text{RBC sample cpm} - \text{bkg.}}{(\text{Hematocrit}) (\text{Vol. of blood washed})}$$

$$\frac{\text{Red Blood Cell Mass} = \text{Total Counts Administered}}{\text{Red Blood Cell cpm/ml.}}$$

RESULTS

The red cell mass in normal adults has been reported as 29.5 to 32.7 ml/kg body weight.

MEASUREMENT OF RED CELL SURVIVAL WITH RADIOCHROMIUM

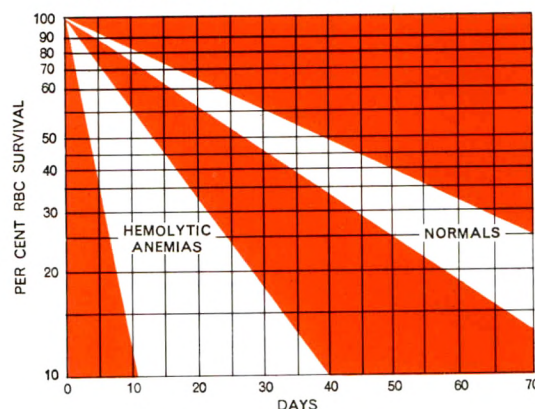
Radiochromate labelled cells may also be used for estimating red cell survival. After labelling a sample of the patient's own cells as described above, they are reinfused. A blood sample is taken at 24 hours to serve as the standard for comparison with subse-

quent samples taken at twice-weekly intervals for about two weeks.

The radiochromate label remains on the red cells until they are removed from the blood for destruction (except for a small amount of leaching which averages about 1 percent of the label present per day). The chromate released on destruction of the cells does not relabel other cells.

TYPICAL PROCEDURE

1. Draw 10 ml. blood samples twice weekly for 2 weeks and discharge carefully into blood bottles containing anticoagulant.
2. Mix blood well and pipette 3 ml. into plastic counting tubes. Cap well.
3. Count all samples in a well scintillation detector at end of study.
4. Plot cpm/sample as ordinate on semilog paper against time in days as abscissa. Determine half-life of cells.



Typical values—Chromium-51 RBC Survival

RESULTS

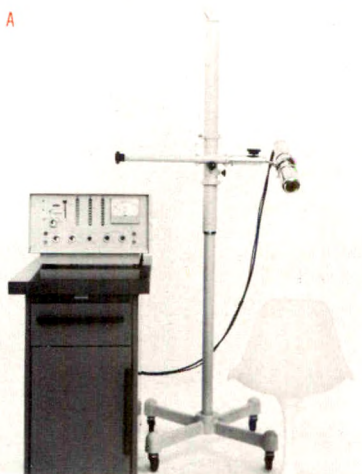
The Cr-51 disappearance curve appears to have three components: a rapid initial drop due to removal of nonviable labelled cells, a second phase lasting about 20 days and corresponding to the exponential removal of cells, a third slower rate. The mean half-time of survival of normal cells is 26 days. In hemolytic anemias the half-time of survival may fall to 5 days.

REFERENCES

1. R. C. Reed: *N. Eng. J. Med.* 250: 1021-1027 (1954).
2. M. M. Strumia, L. Taylor, A. B. Sample, L. S. Colwell and A. Dugan: *Blood*, 10: 429-440 (1955).

NUCLEAR-CHICAGO SYSTEMS FOR IN-VIVO NUCLEAR MEDICINE

A



Nuclear-Chicago's extensive line enables the clinician to choose a system specifically designed to meet his needs and budget. Shown above are three complete systems for thyroid uptake measurements and similar applications.

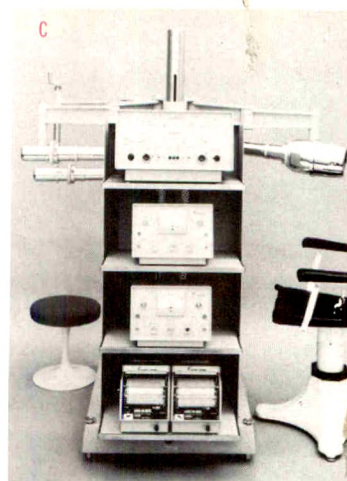
Photograph A illustrates a basic system which combines the 181B Decade Scaler, DS-101 Scintillation Detector, and the SA1 Detector Stand. A second arm and detector can be added to the stand for conversion to kidney function studies as in photograph D.

B



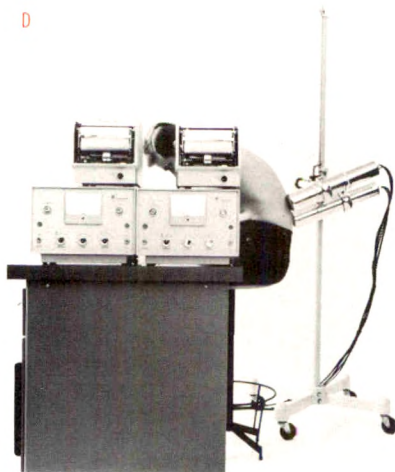
A more versatile single-detector system is shown in photograph B. Here the DS-201 two inch crystal Detector is mounted on the SA2 Detector Stand which provides a shelf for the 132B Scaler/Spectrometer or other clinical scaler.

C



Nuclear-Chicago's most versatile *in-vivo* system (C) includes the DS-301 three inch crystal Detector and 132B Scaler/Spectrometer for thyroid uptake measurements. Two additional arms and probe detectors, two ratemeters, and two recorders are provided for kidney function studies.

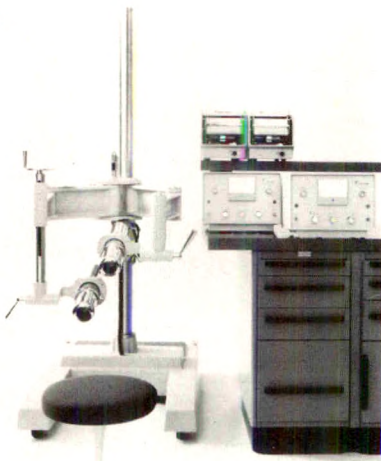
D



Nuclear-Chicago's basic kidney function system is shown in photograph D. It consists of two DS-101 Detectors, two 1620BS Ratemeters, two R1000A Chart Recorders, and the SA1 Stand equipped with a second arm. A more versatile system is shown in photograph E. Here the 1710 Stand is used instead of the SA1. A motor in the center column automatically raises or lowers the arms to the desired position. This system can be expanded as the needs of the laboratory increase. An instrument rack and third arm can be added as shown in photograph C.

Nuclear-Chicago offers the most advanced system commercially available for scanning body areas for radioisotope concentrations. The 1705 Dual Scanner shown in photograph F with the DS-301 Scintillation Detector and 132B Scaler/

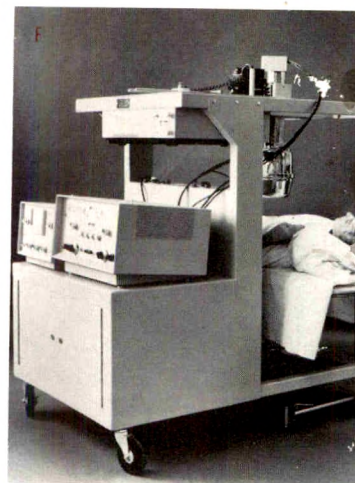
E



Spectrometer provides both printed and photographic records of the distribution of radioisotopes in body organs. The 1705 has been successfully used in brain, kidney, thyroid, and liver scanning. The system can be used in thyroid uptake measurements by merely changing collimators.

Complete descriptions of instruments shown here can be obtained by writing for General Catalog S.

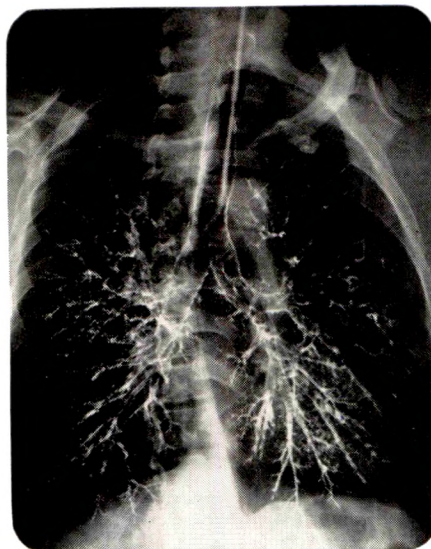
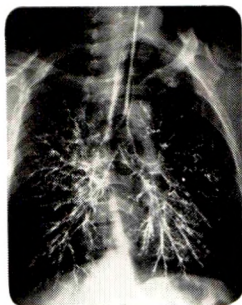
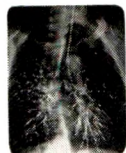
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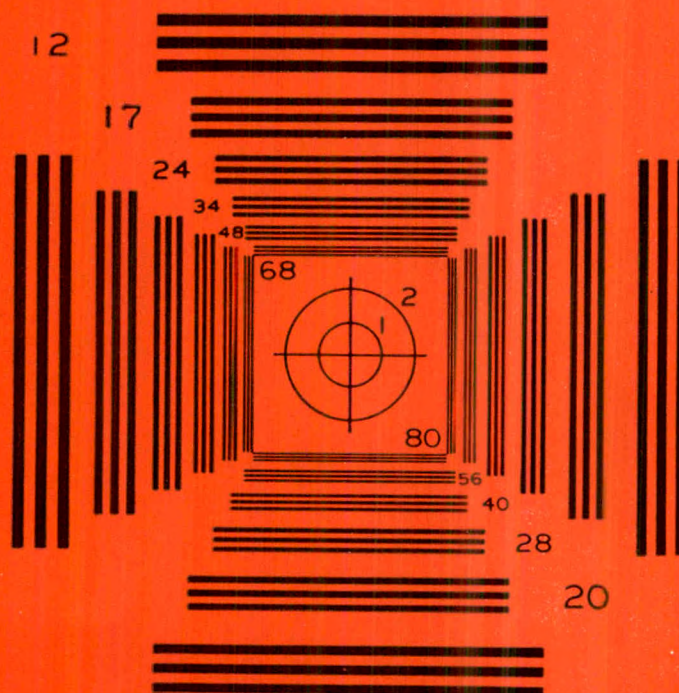
Consult product brochure for complete information on administration, side effects, precautions, and contraindications.

Hytrast is presented in 25 ml. vials containing 20 ml. of a sterile aqueous suspension containing 50% w/v of combined iodine as a mixture of N(2,3-propylidol)-3,5-diiodopyridone-4 and 3,5-diiodopyridone-4.

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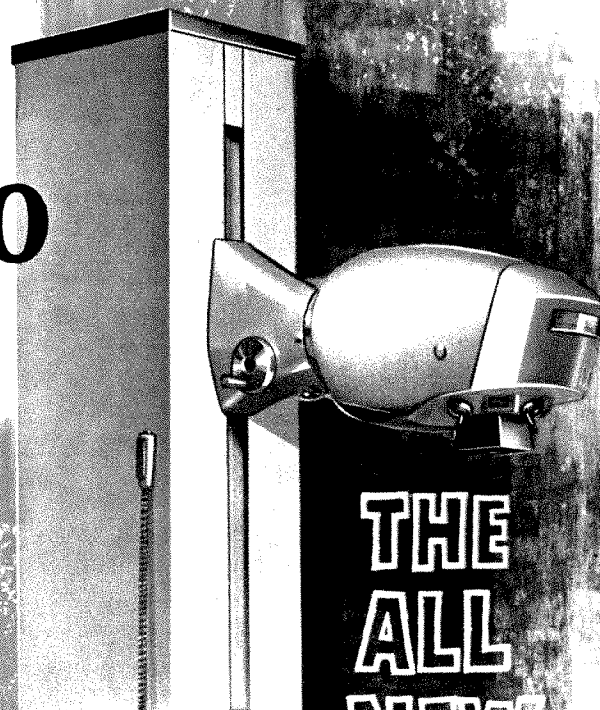
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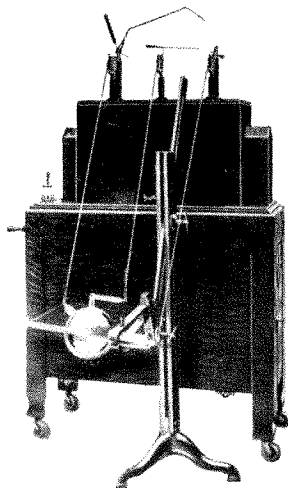
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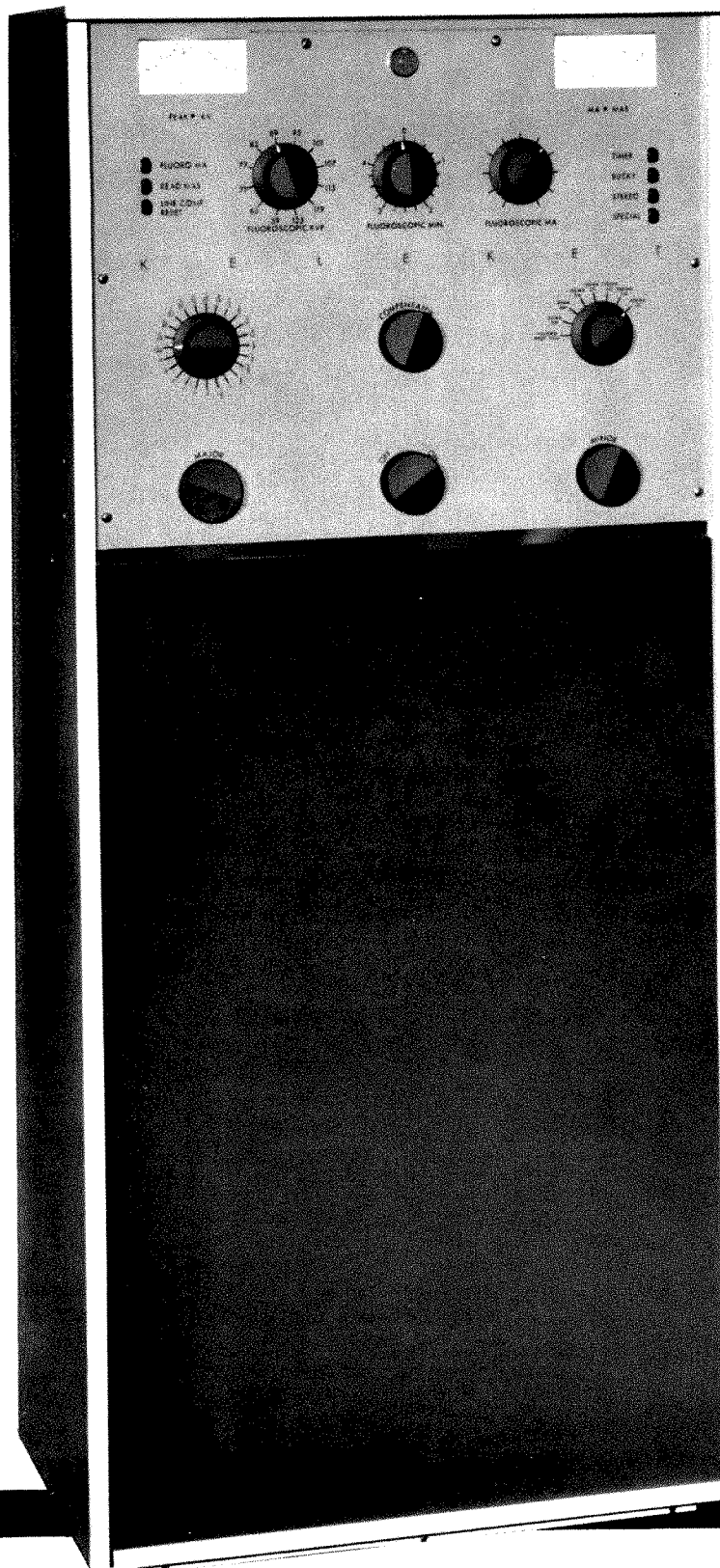
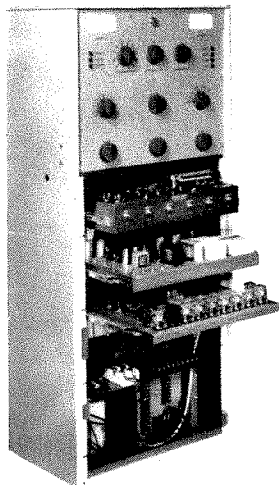
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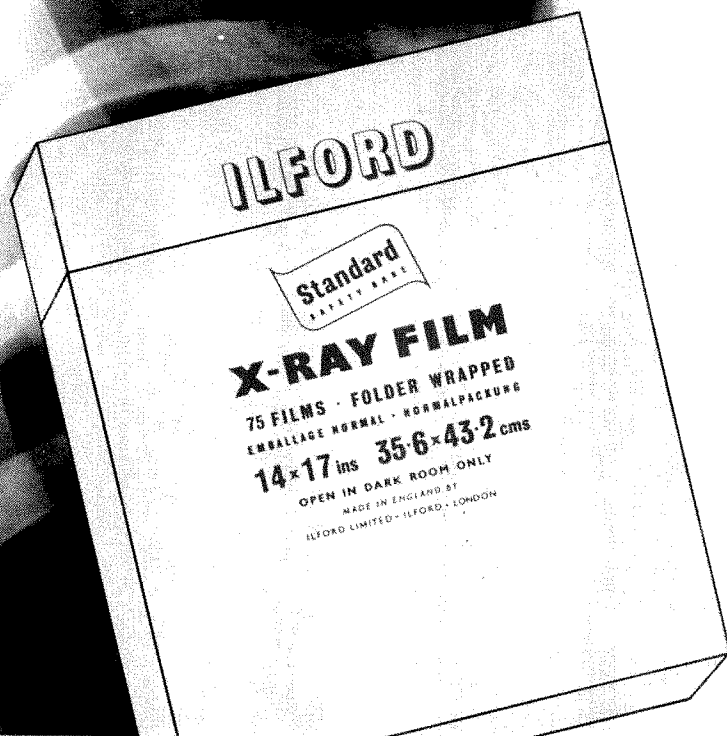
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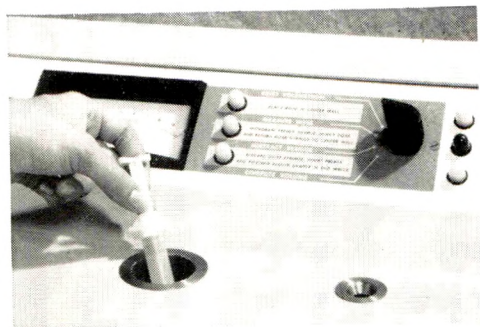
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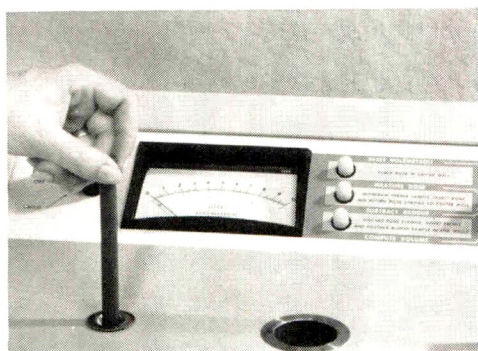
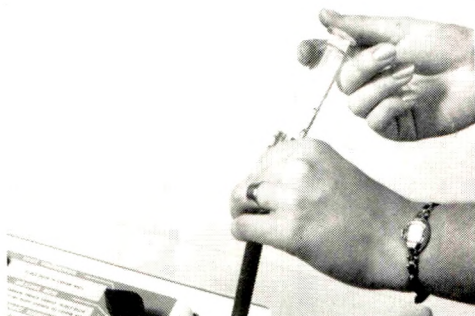
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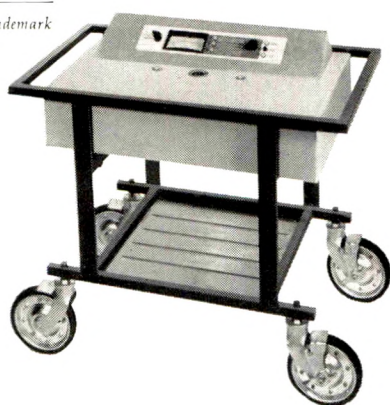
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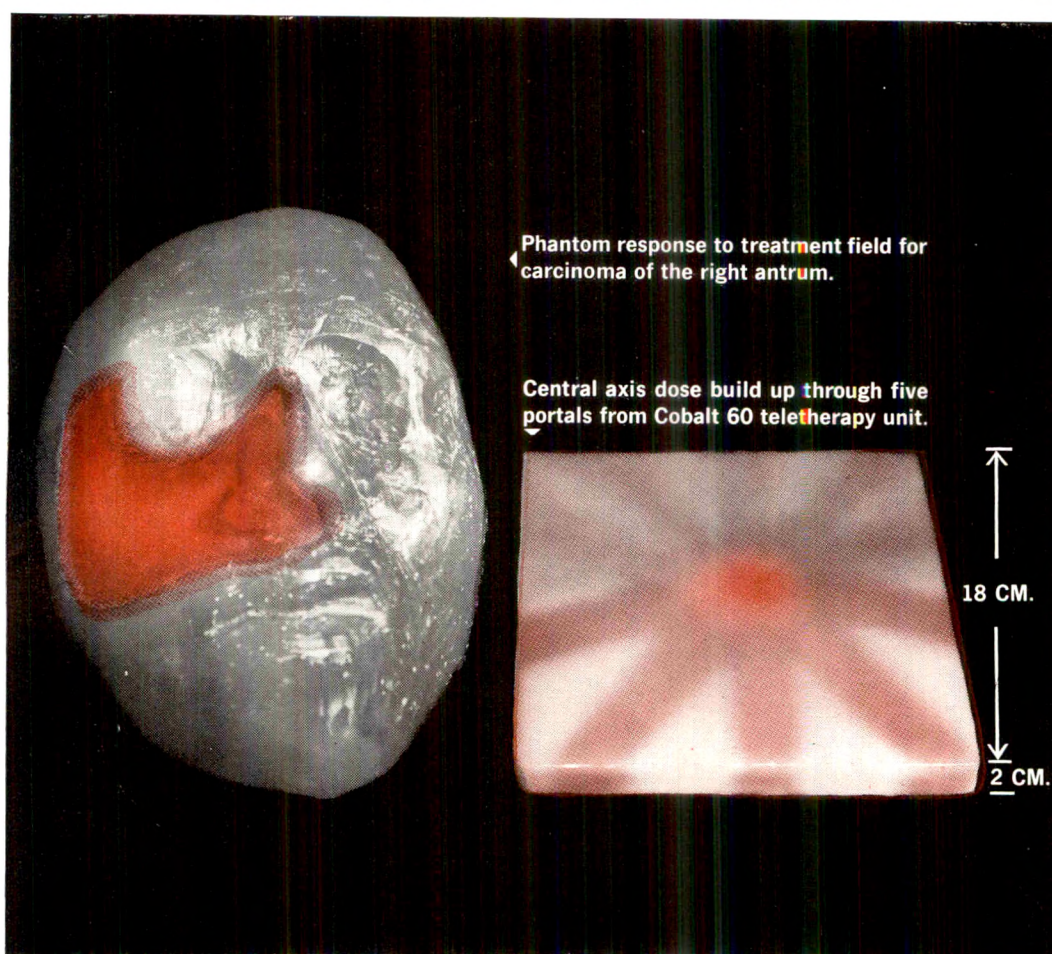
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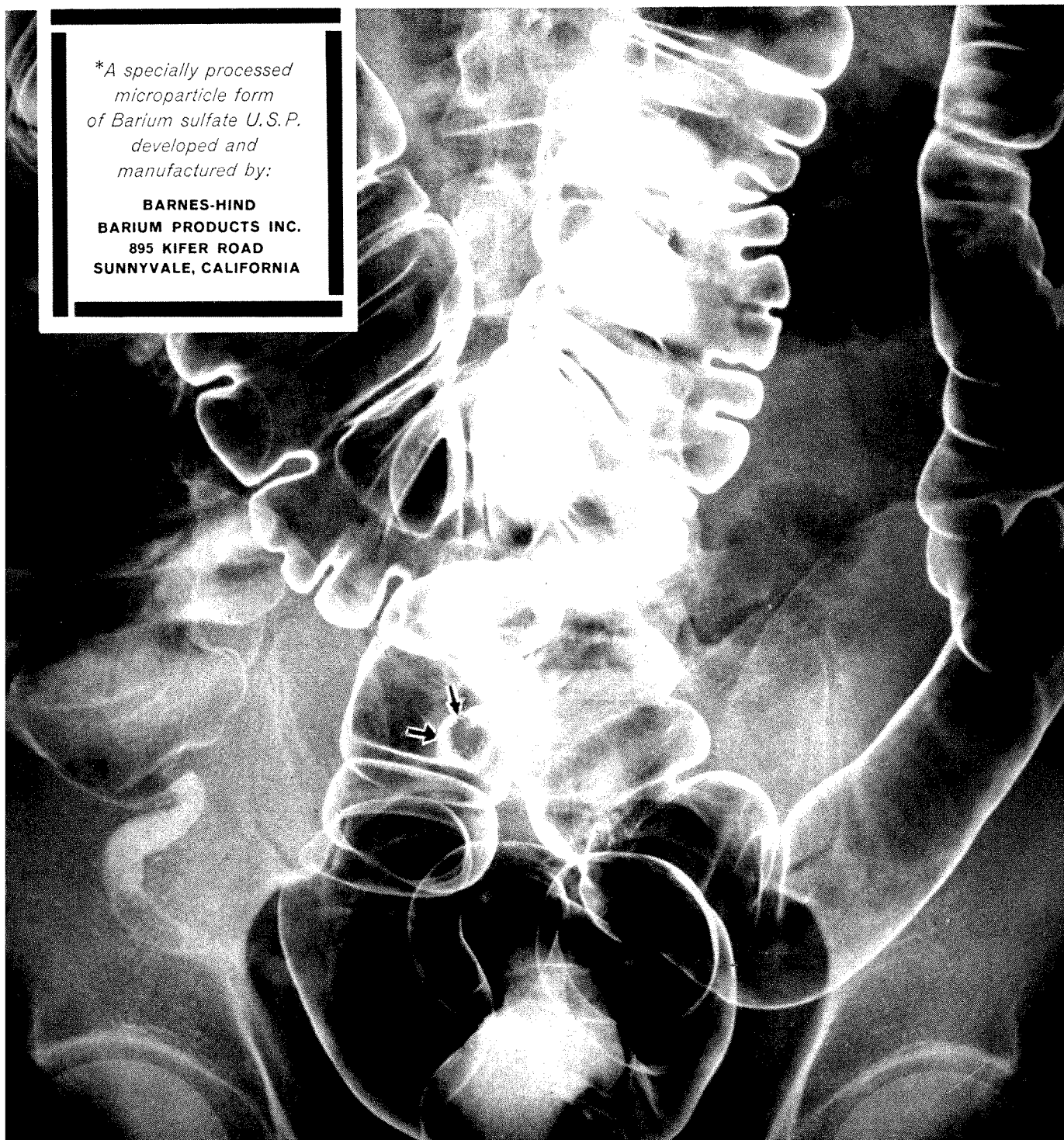
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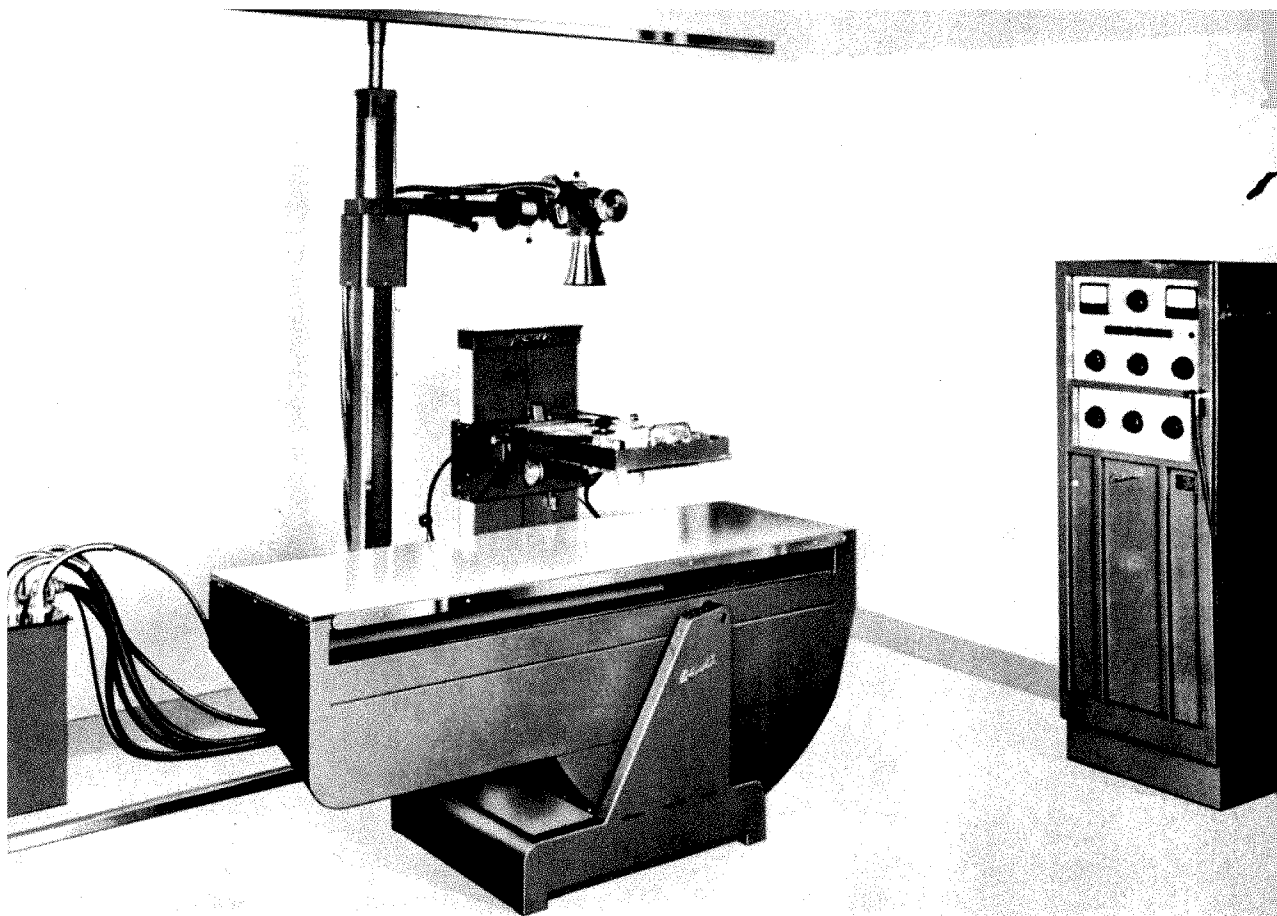
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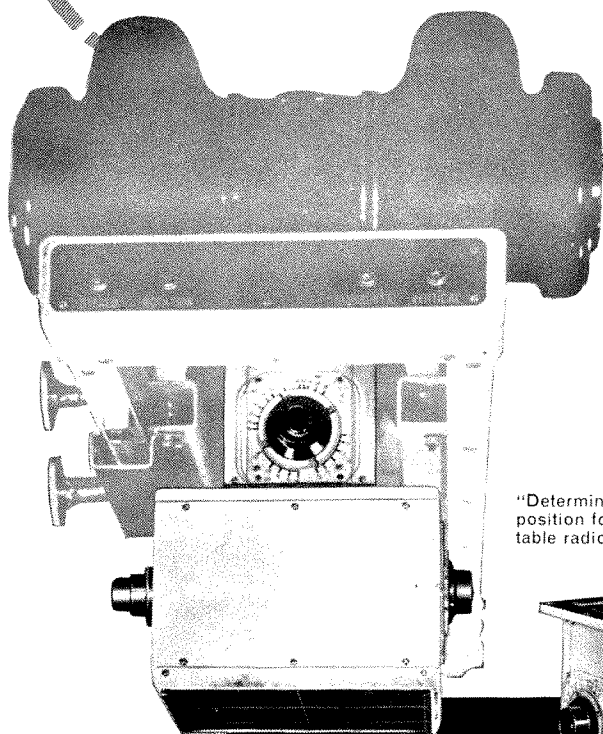
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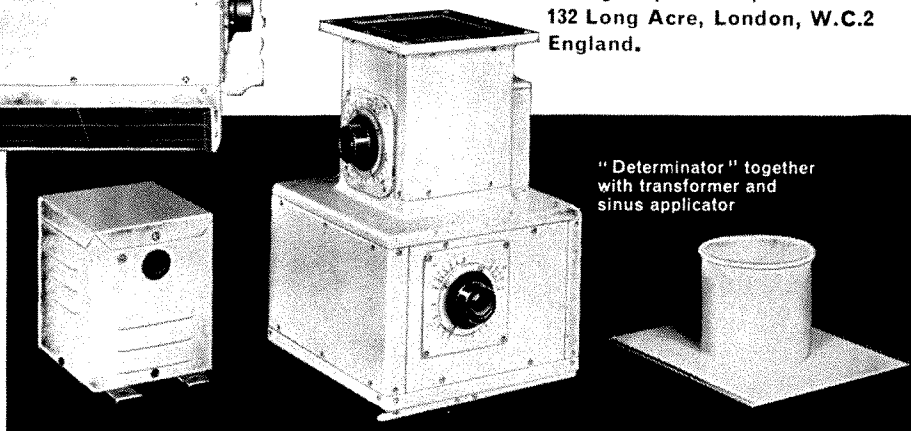


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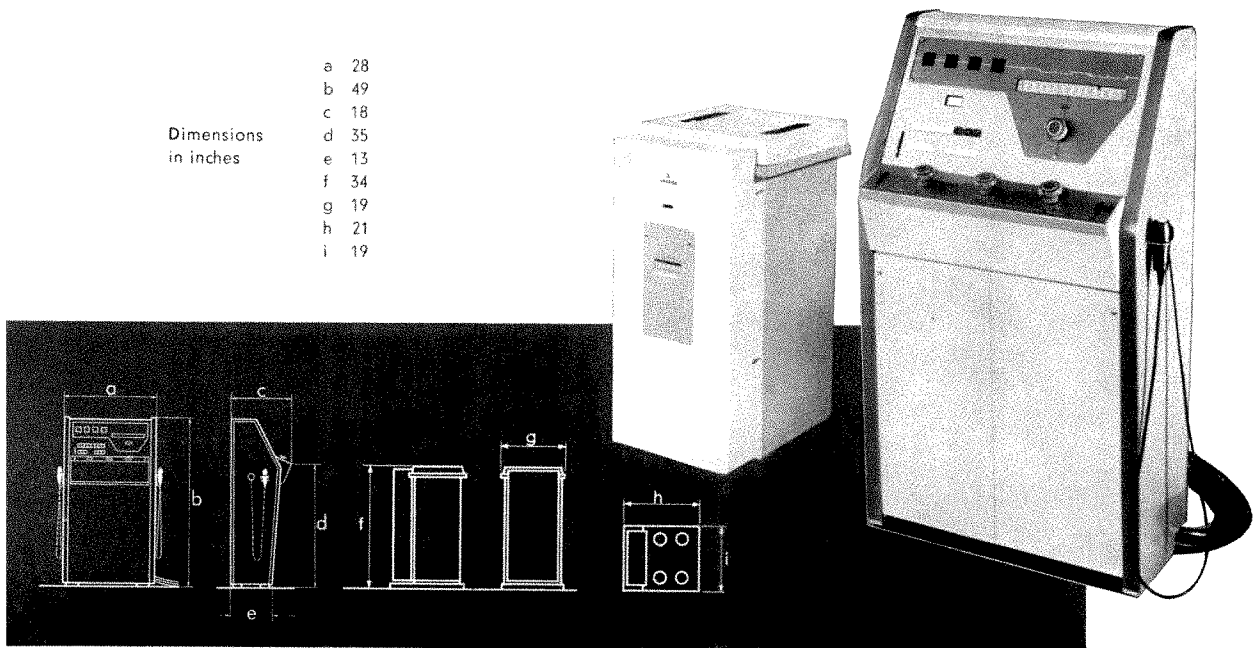
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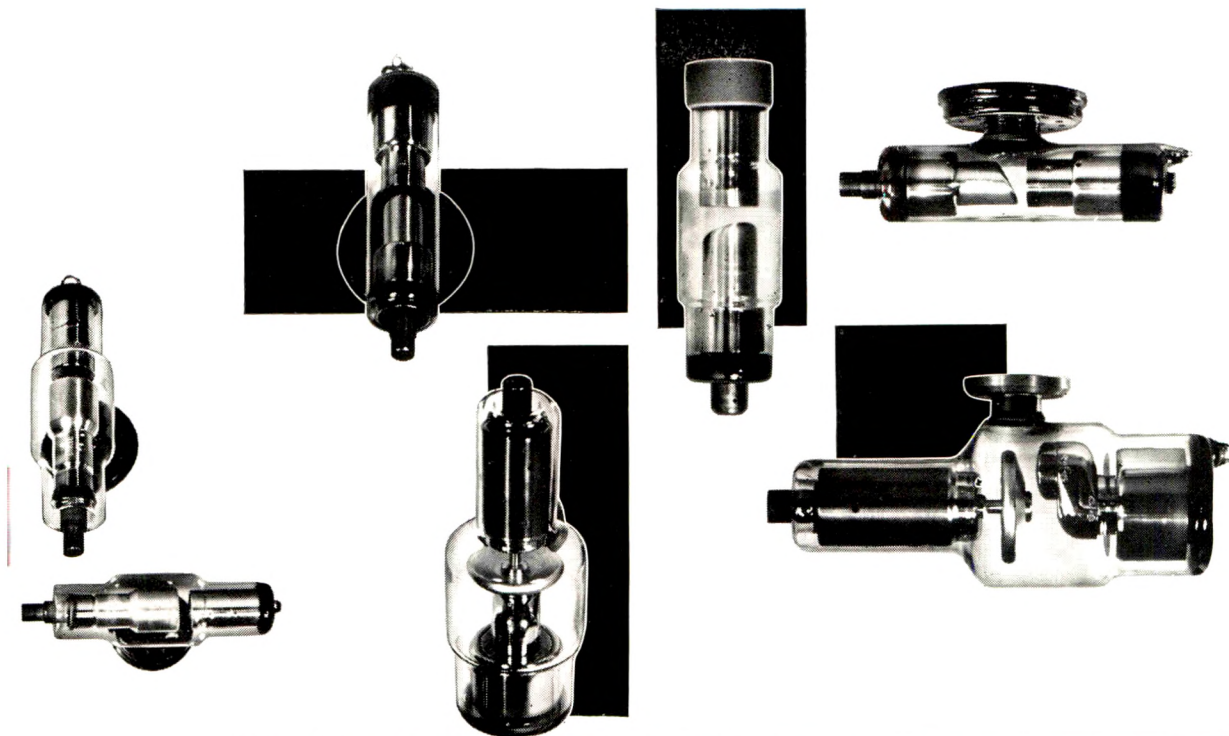
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in inches

a 28
b 49
c 18
d 35
e 13
f 34
g 19
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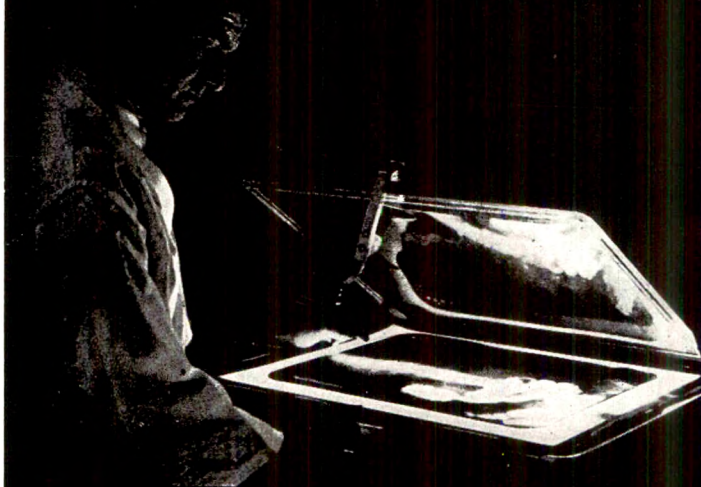


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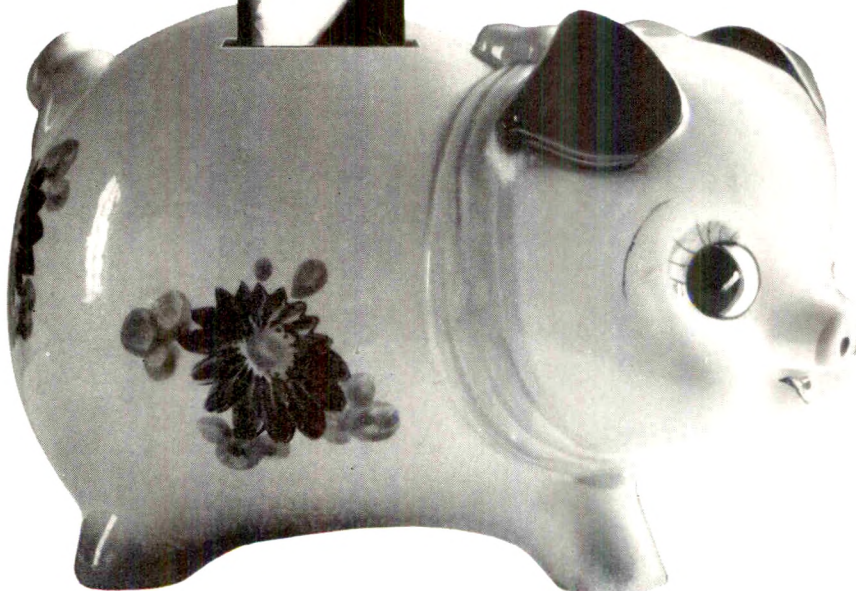
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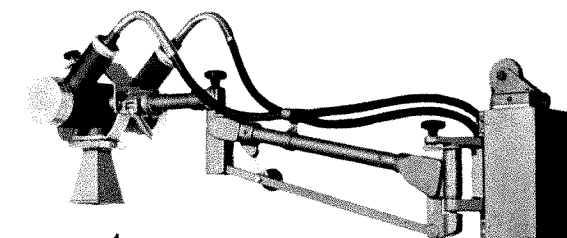
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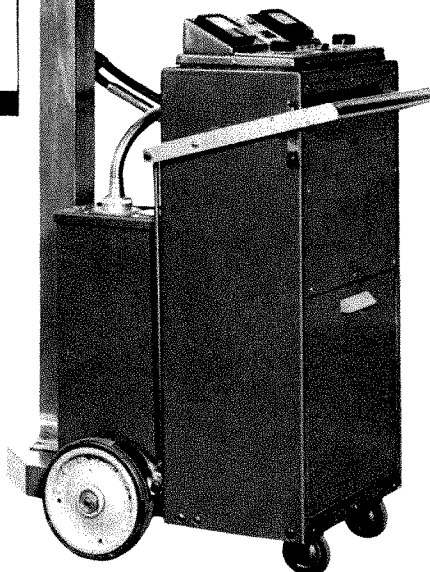
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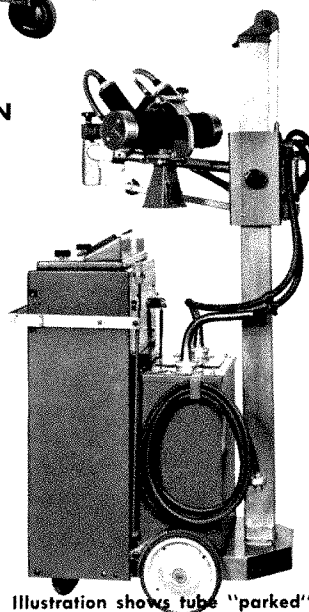
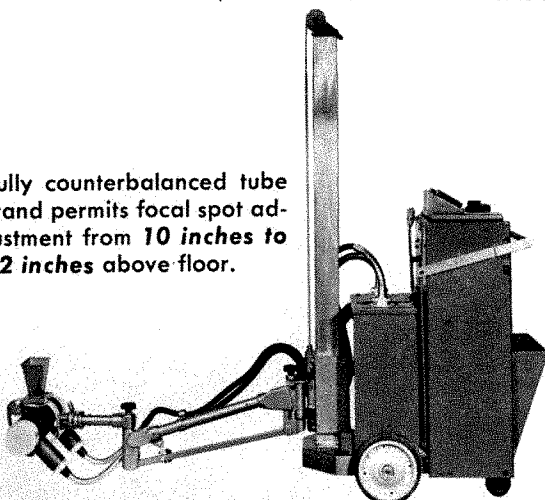
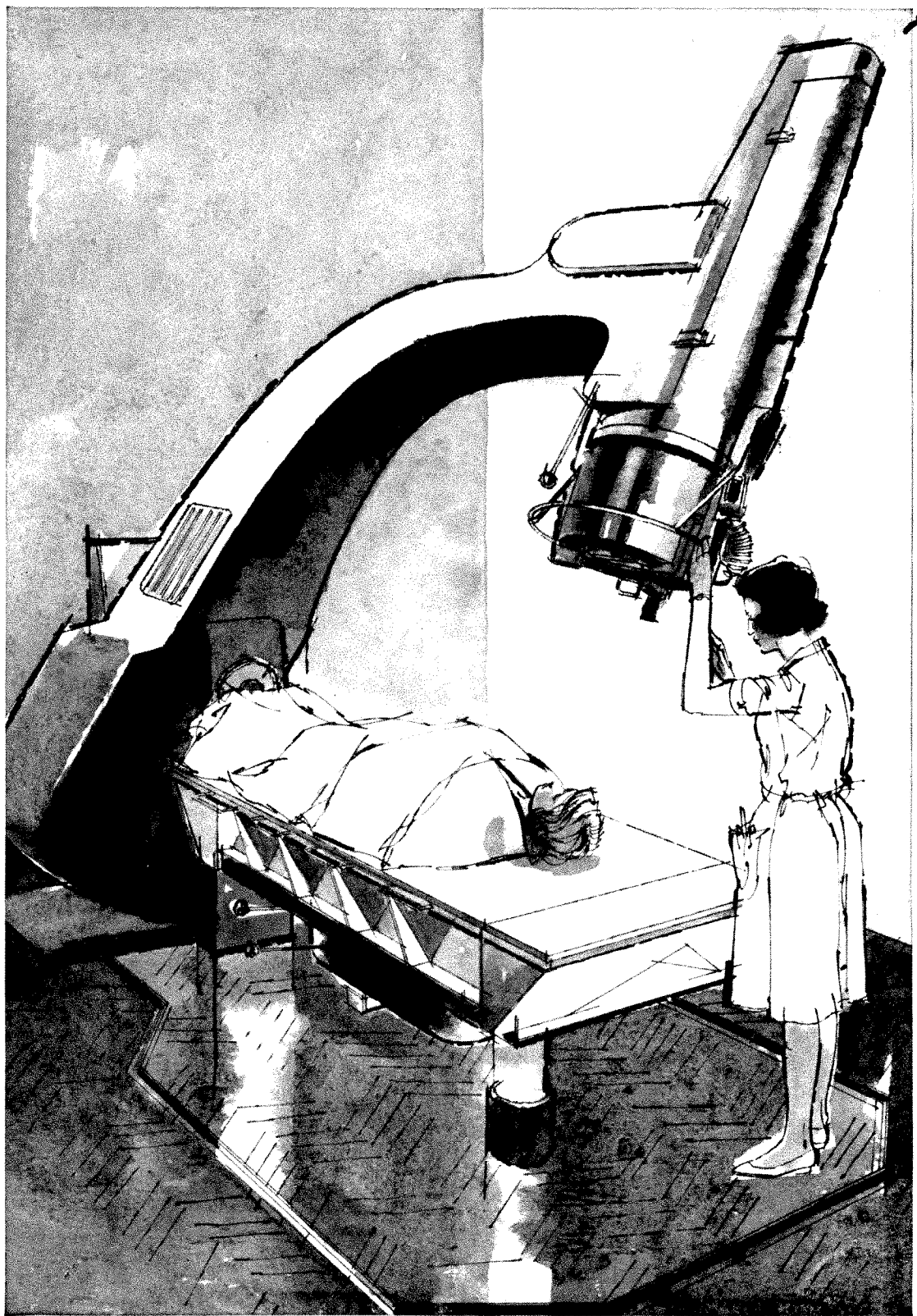
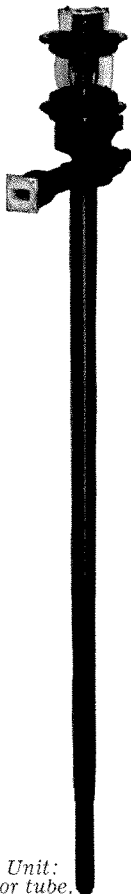


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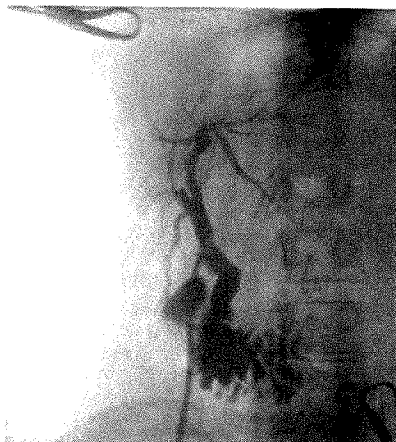
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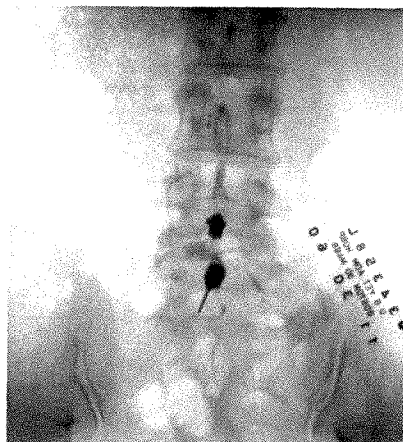
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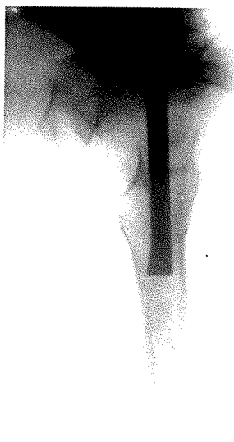
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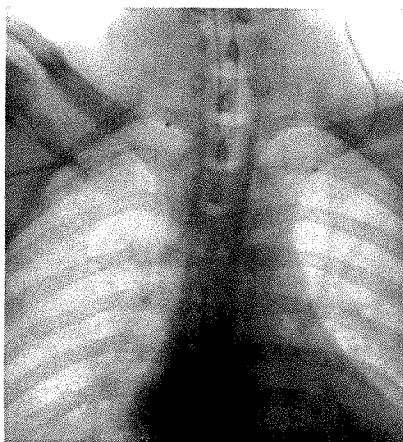
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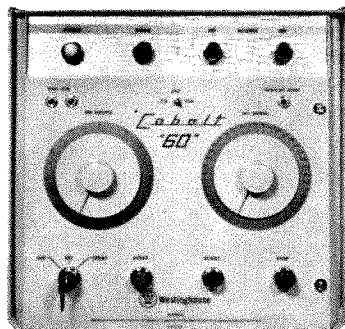
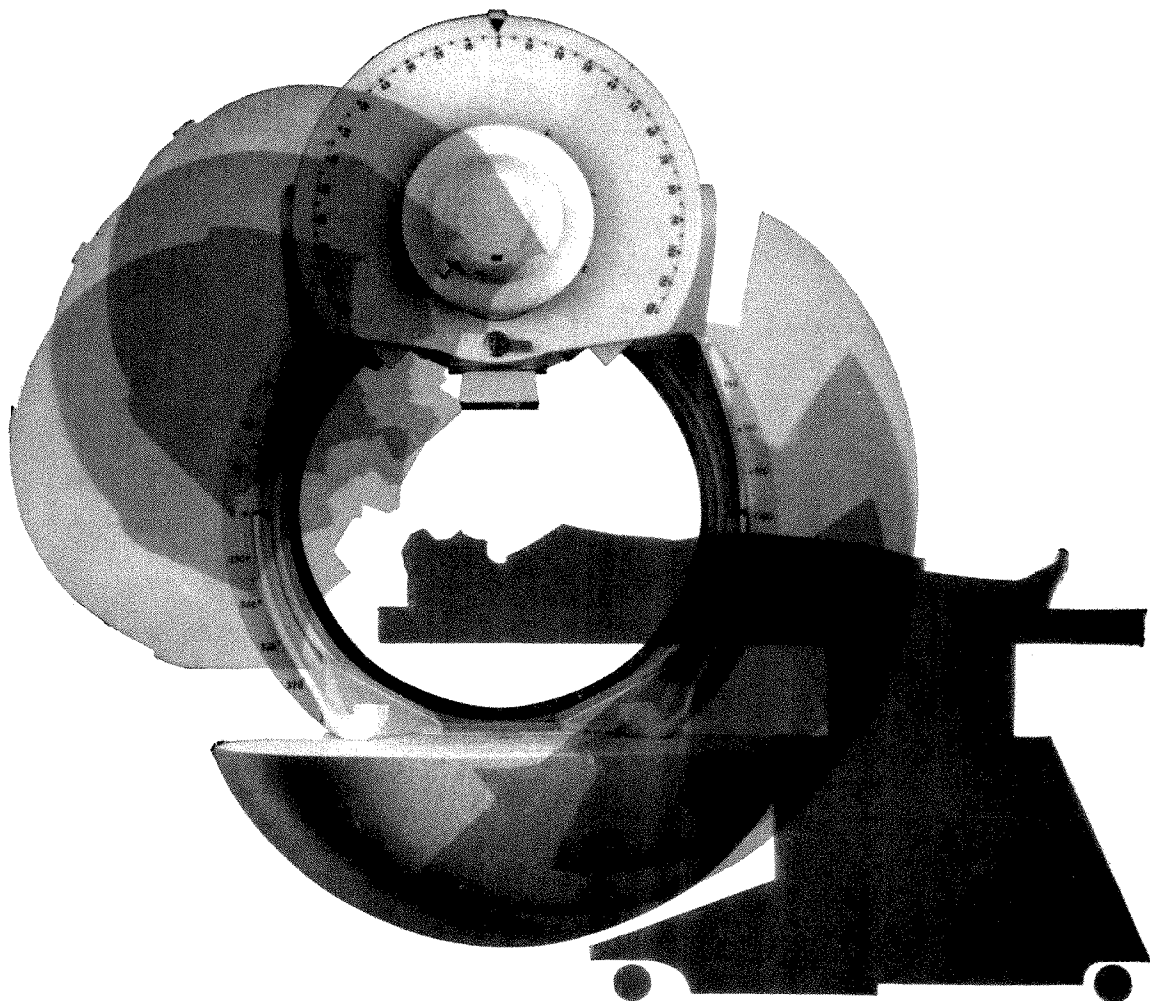
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THE VOLUME OF THE SELLA TURCICA*

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ANATOMIC studies on the size of the sella turcica have been carried out at the end of the last century and the beginning of the present one, and are well summarized in the encyclopedic monograph of Karlas.³⁷

Roentgenologic measurements of the sella have also been made by many authors, but with few exceptions these have been limited to the length and depth of the sella on the lateral roentgenogram, or to the area of the lateral profile.

GENERAL CONSIDERATIONS

It is a basic requirement of good roentgenography that anatomic structures be studied by methods capable of revealing them in 3 dimensions; failure to do so invites misinterpretation. As the third dimension (width) of the normal adult sella turcica may be quite variable—from 8 to 19 mm. (Fig. 1, *a*, *b*, *c*, and *d*)—it is scarcely surprising that knowledge of only the length and depth, or of the area, does not provide a reliable estimate of its size. Thus the observation has several times been made^{39,44,49,54} that 2 sellae with similar lateral contours might harbor pituitary

glands of very different size, or that pituitary glands of the same size might be found in sellae of very different lateral dimensions.^{44,54} Our experience is in agreement: a sella apparently small in the lateral view (Fig. 2*a*) may have a large transverse diameter (width) as demonstrated in the posteroanterior view (Fig. 2*b*), with a total volume well within normal limits. The reverse situation may also be seen: a sella may appear large in the lateral view (Fig. 3*a*) but prove to be narrow when viewed sagittally (Fig. 3*b*). Of considerable practical importance is the fact that it is possible that a sella be pathologically widened (Fig. 4*b*) and yet retain a relatively normal lateral contour (Fig. 4*a*).

Because the length and depth alone do not give an adequate evaluation of sellar size, various attempts have been made to gauge the width of the sella. Basically, these attempts aim at the demonstration in sagittal views of the dorsum, the floor, or the anterior wall of the sella. The half-axial anteroposterior view with 40° to 20° caudal angulation of the central beam (the Chamberlain-Towne or Valdini-Haas view) permits visualization of the dorsum, as first

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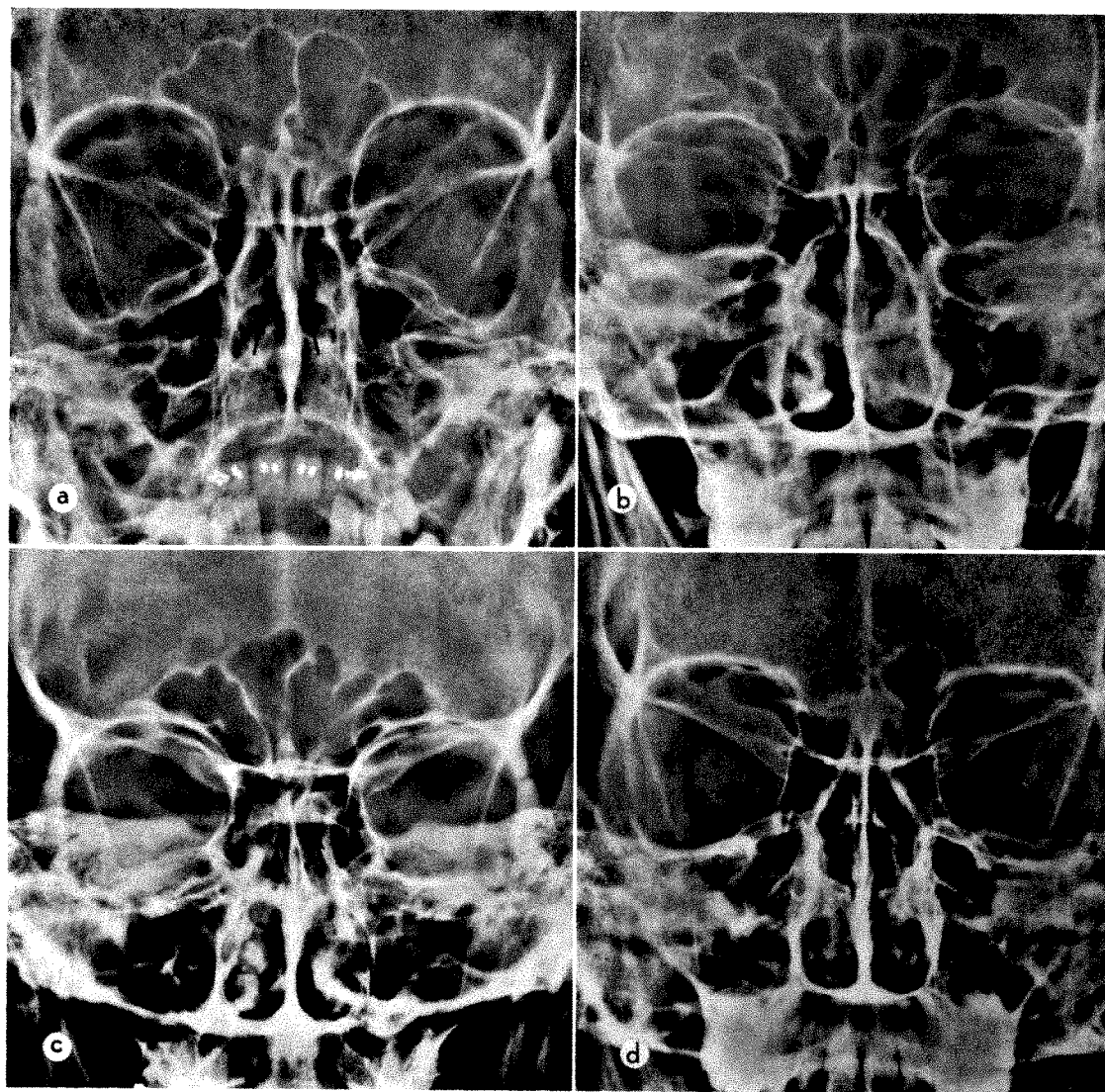


FIG. 1. (*a*, *b*, *c* and *d*) Various types of sellar floor in posteroanterior view.

demonstrated by Busi and Balli¹⁰ in 1910–1911. Haas,^{29,30} Valdinj,³⁵ Scheuermann,³¹ Erdélyi,¹⁹ Meldolesi and Pansadoro,⁴¹ Far-
 ñas²¹ and Gilormini²⁷ have all used this projection to visualize the dorsum and posterior clinoids. Dilenge¹⁶ discussed in some detail the effect of different degrees of angulation of the central beam upon visualization of the sella in anteroposterior and posteroanterior views, and Etter²⁰ has described a method which permits consistent visualization of the dorsum in the half-axial view. Meldolesi and Pansadoro⁴¹ first proposed the use of the narrowest trans-

verse diameter of the dorsum for the evaluation of sellar width. Block and Joplin⁵ also suggested use of the narrowest width, the “waist”, of the dorsum (Fig. 9*a*).

In 1926, Schüller³³ published a straight sagittal view of the skull in which the floor of the sella was clearly seen. Although he had previously³² (1912) commented that “the breadth of the fossa would be of importance in deciding as to the shape and size” of the sella, apparently he pursued the subject no further. Hare, Silveus, and Smedal³² recognized the floor of the sella in sagittal views, as did Mayer⁴³ and Berger-

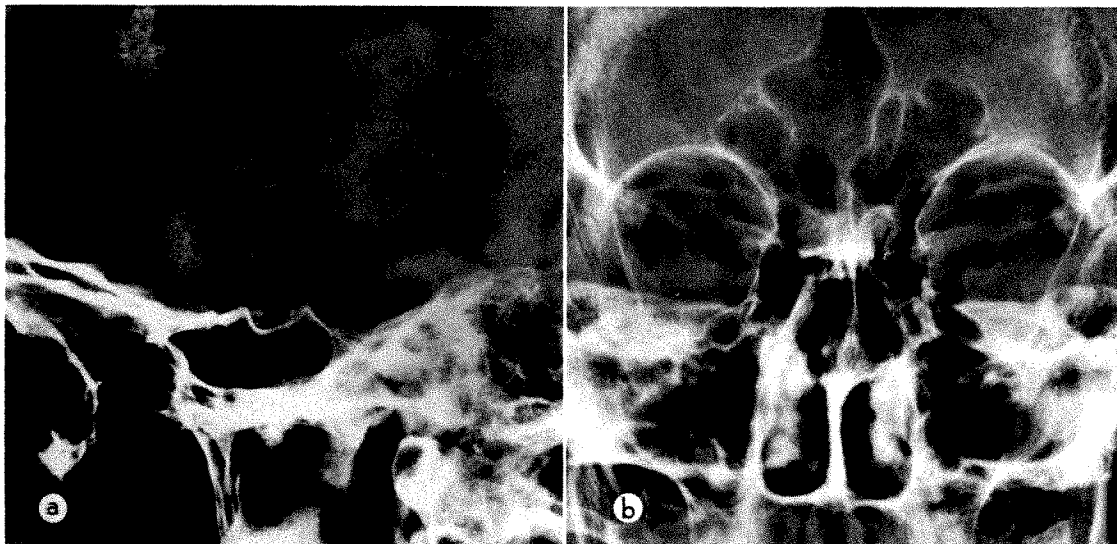


FIG. 2. (a) Relatively small sella in lateral view. Its width (b) is, however, larger than usual so that sellar volume is well within normal limits.

hoff.⁴ Laminagraphy has been used for the observation of the transverse diameter of the floor of the sella by Vallebona and Conte,⁵⁶ Cardillo and Bossi,¹¹ and by Fischgold, Huc and Fissore,²³ Gilbert-Dreyfus *et al.*,²⁶ Fischgold, David and Brégeat,²² and Bourdon.⁷ Di Chiro¹⁴ has shown that it is possible to recognize the floor of the sella on approximately 90 per cent of plain posteroanterior or anteroposterior skull roentgenograms.

The sellar width may also be evaluated in

the submentovertical (axial) projection. In our experience, the anterior aspect of the dorsum with its slight and smooth anterior concavity (Fig. 5) was visualized in 66 per cent of 160 cases of technically satisfactory submentovertical roentgenograms. At the VI Symposium Neuroradiologicum 1961, Radberg¹⁸ reported that in 70 per cent of cases he could demonstrate the anterior wall of the sella and in 65 per cent he could recognize the carotid sulci at each side of the sellar wall (Fig. 6). The distance be-

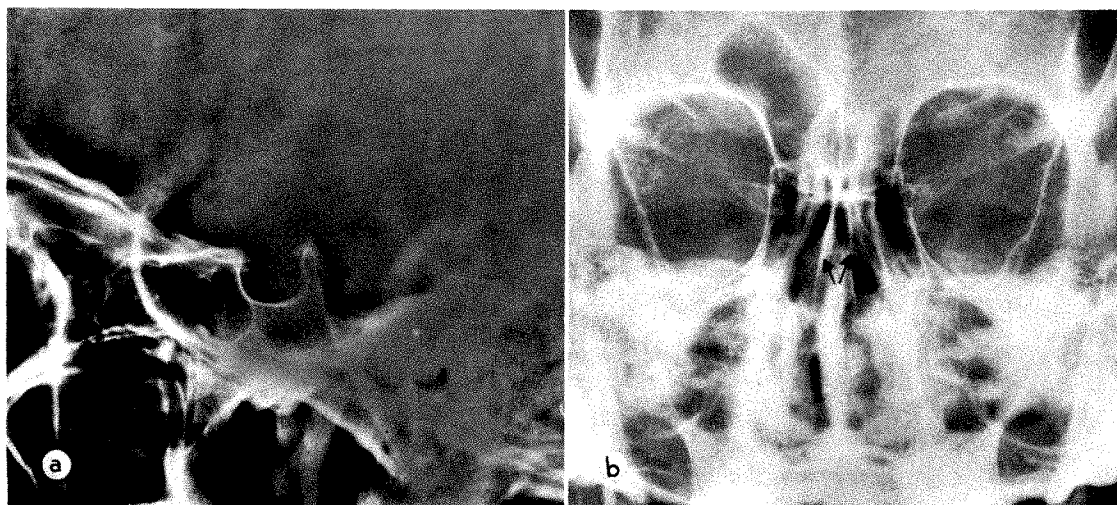


Fig. 3. (a) Rather large sella in lateral view but (b) narrow in posteroanterior view.

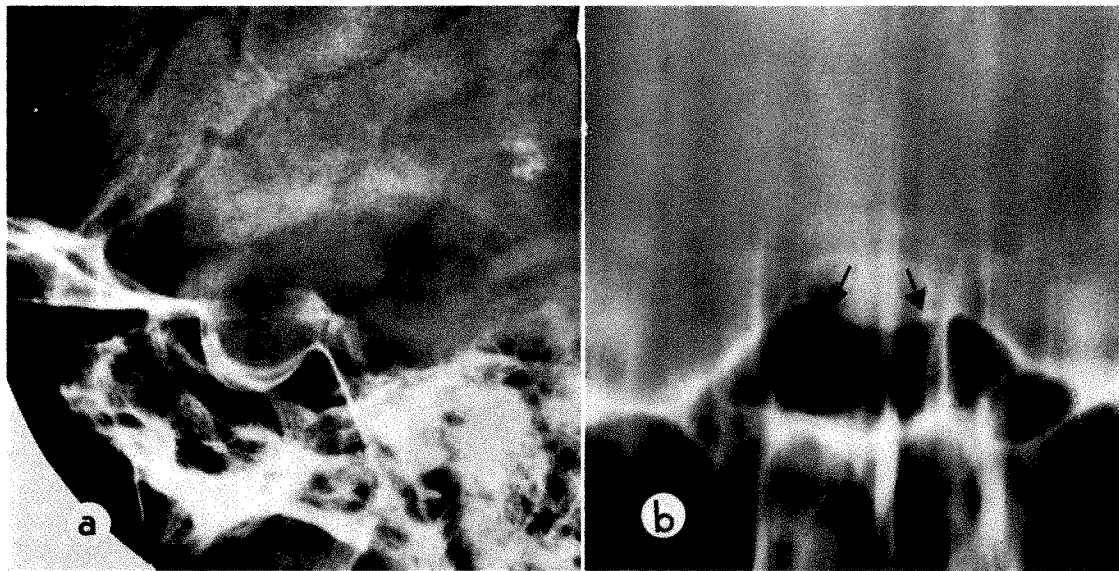


FIG. 4. (a) Borderline sella in lateral view but (b) unquestionably pathologic in sagittal view.

tween the anterior wall of the sella and the anterior aspect of the dorsum gives a measure of the length of the sella (Fig. 7a), and hypothetical lines between the lateral extremes of these contours set the lateral limits of the sella, and thereby provide a measure of the width in the axial view (Fig. 7b). In pathologic cases, one may observe in the submentovertical projection the lengthening (Fig. 8a), and lengthening and widening (Fig. 8c) of the sella; such

information augments and confirms the data obtainable from other views (Fig. 8, b, d and e).

In the lateral projection, then, one may measure the length and depth of the sella. Usually posteroanterior and anteroposterior views permit measurement of the width; often axial views yield information as to the width, and sometimes as to the length.

There are thus 4 possible approaches to the measurement of the transverse diameter



FIG. 5. Contour of anterior aspect of dorsum in axial view.



FIG. 6. Anterior sellar wall in axial view (central arrows) with carotid sulci on each side (lateral arrows).

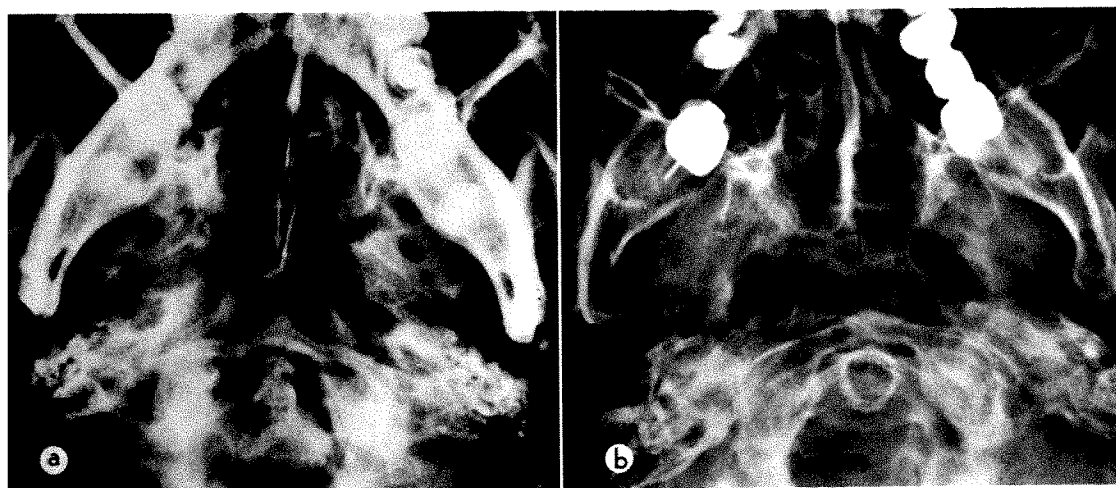


FIG. 7. (a) Sellar length measured in axial view between anterior sellar wall and anterior aspect of dorsum. (b) Sellar length and width measured in axial view.

of the sella: the width of the dorsum at its "waist" or narrowest point, the width of the floor, and the widths of the 2 contours in the axial view which represent respectively the anterior and posterior sellar walls. Karlas³⁷ mentioned that the width of the sella is not precisely the same over its whole length, so that one might expect the values for the width to vary somewhat when the 4 different measurements are used. In

fact, we found the anterior aspect of the dorsum in the submentovertical view to average 12.4 mm. in 106 cases (Graph 1), while the average diameter of the floor in the posteroanterior view was 12.9 mm. in 270 cases (Graph 11). The 2 values differed by zero to 2 mm. in 95 per cent of 106 cases. Width of the "waist" of the dorsum may correspond closely to the width of the sellar floor (Fig. 9b); this is not consistent,

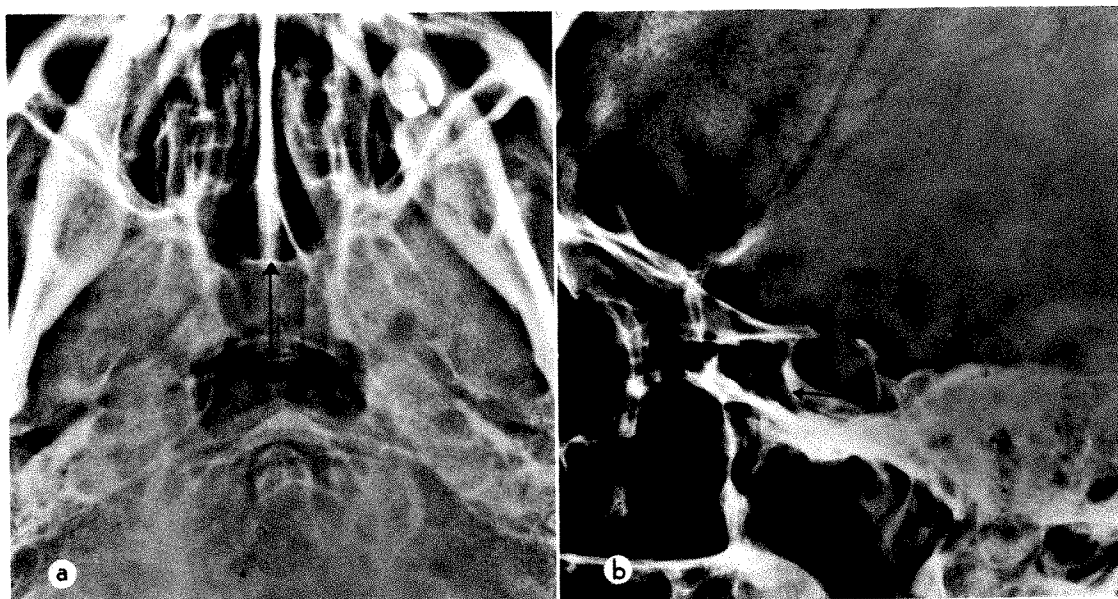


FIG. 8. (a) Sellar length measured in axial view in a case of intrasellar adenoma. Corresponding increase in length in lateral view (b).

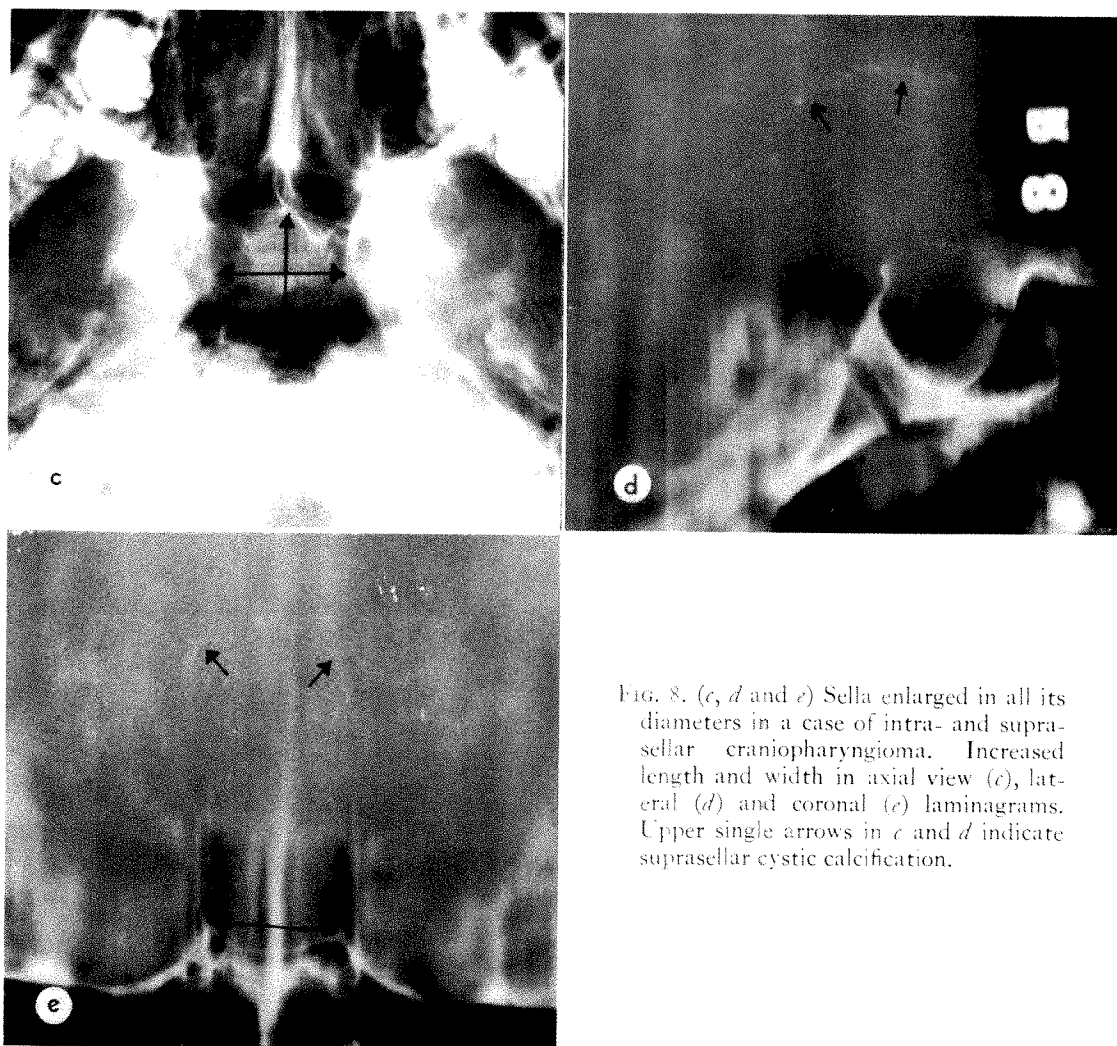
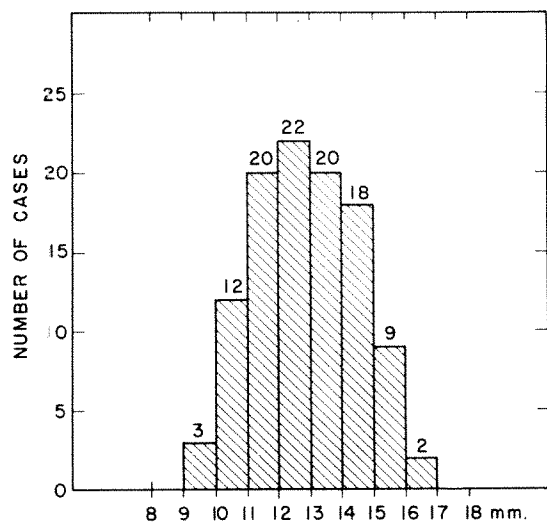


FIG. 8. (*c*, *d* and *e*) Sella enlarged in all its diameters in a case of intra- and suprasellar craniopharyngioma. Increased length and width in axial view (*c*), lateral (*d*) and coronal (*e*) laminagrams. Upper single arrows in *c* and *d* indicate suprasellar cystic calcification.

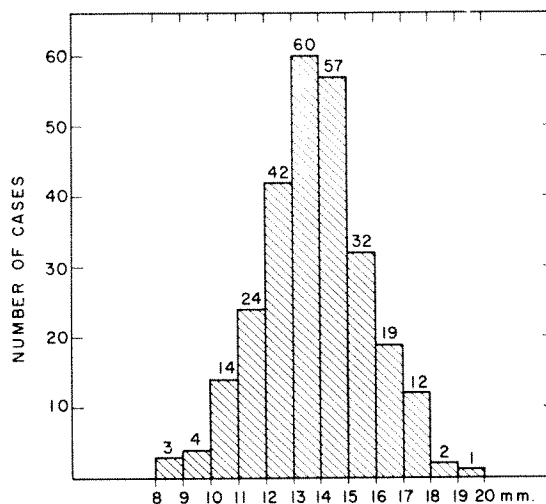
however, and Cardillo and Bossi¹¹ illustrate the discrepancy which may occur between "waist" and floor. In 46 cases, we found the "waist" to average 18 mm., a value considerably larger than revealed by other measures of width. The width of the anterior wall of the sella averaged 12.8 mm. in 17 cases, and was within zero to 2 mm. of value for the anterior aspect of the dorsum in all 16 cases in which we compared them. The anterior sellar wall in the axial view agreed within 2 mm. with the width of the floor in the posteroanterior view in 11 of 12 cases (92 per cent); in one case there was a difference of 3 mm.

Thus evaluation of the width of the sella by measurement of the floor in standard

posteroanterior views and by means of the anterior and posterior sellar walls gives comparable results. Measurement of the "waist" of the dorsum is less reliable, giving a larger average figure than the other methods. In addition, the dorsum is quite variable in configuration. It often has no definite "waist," and in only 44 per cent of 105 randomly selected half-axial views was it possible to see the dorsum clearly enough for measurement. In a substantial minority of cases, visualization of the anterior and posterior sellar walls in the submentovertical projection is also not obtained. For these reasons, we consider that in most cases the best method for the study of the width is the measurement of the floor of the



GRAPH I. Width of sella in submentovertical projection in 106 normal adults (36 inches focal distance).



GRAPH II. Width of sella in posteroanterior view in 270 normal adults (36 inches focal distance).

sella in standard posteroanterior view of the skull. In the less than 10 per cent of cases in which the floor is not well seen in this view, recourse must be had to one of the other means of measurement. The submentovertical view may also be used in cases in which the floor of the sella in the posteroanterior view is a smooth curve with its convexity upward for, as Radberg has pointed out, in these cases the lateral limits

of the floor are ambiguous. When the plain roentgenograms are not satisfactory for the purpose of measuring sellar width, laminagraphy in the coronal plane will, of course, give the required information. We do not feel that laminagraphy is justified as a routine; it should probably be reserved for questionable cases.

Certain features of the anatomy of the sella make its reliable mensuration difficult under any circumstances. The sella is

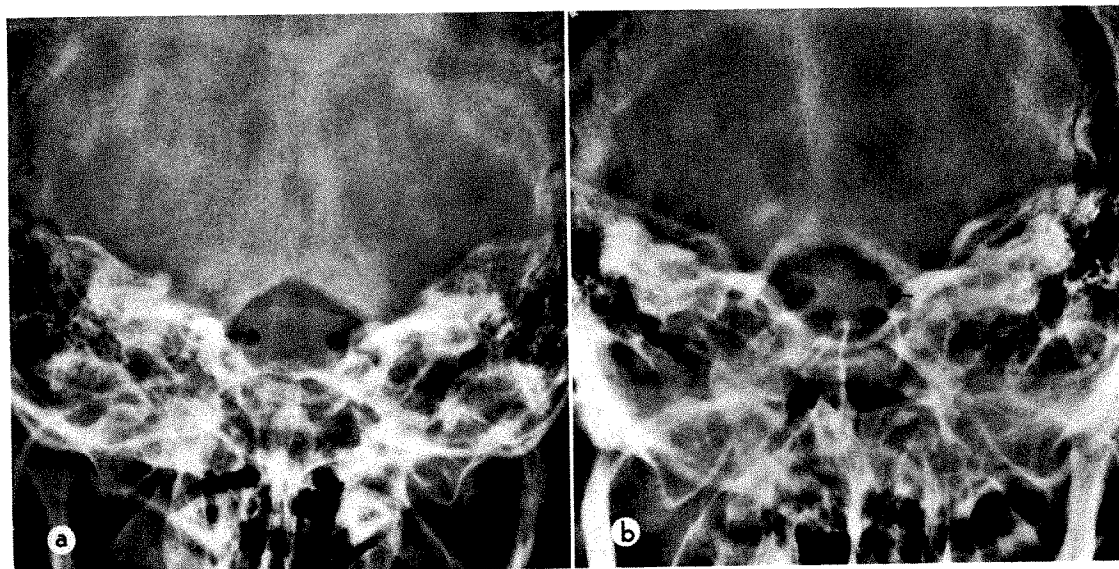


FIG. 9. (a) "Waist" of dorsum. (b) Width of "waist" of dorsum (upper arrows) corresponds to width of floor (lower arrows).

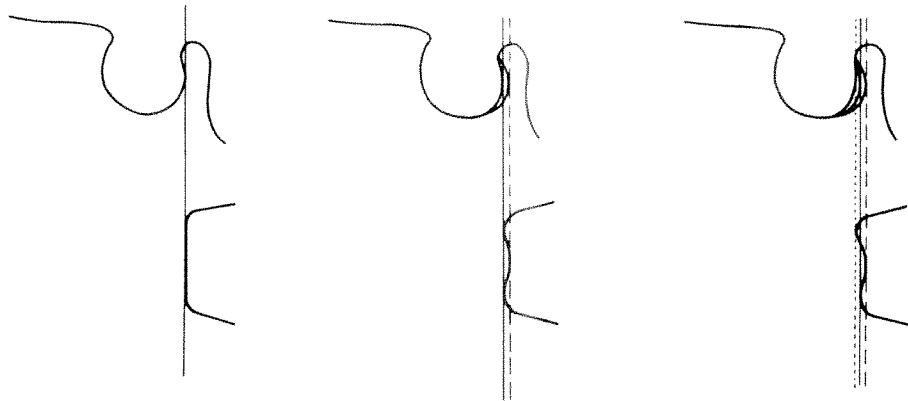


FIG. 10. Single, double, and triple contours of anterior aspect of dorsum in lateral views (top sketches) and corresponding contours of anterior aspect of dorsum as demonstrated in axial views (bottom sketches).

bounded on 3 sides by bone, but non-bony reference points must be decided upon for the lateral and superior surfaces. There is also some ambiguity as to the most suitable reference point on the posterior margin. Because the dorsum is not flat, but a curve with the concavity forward, the central point of the dorsum is posterior to the lateral margins. Three distinct contours, the center and the 2 lateral extremes, may be recognized on some lateral roentgenograms of the sella (Fig. 10).

In a high proportion of skulls (92.4 per cent of 171 in Karlas' series³⁷), there is a small depression on the posterior sella which accommodates part of the posterior lobe of the pituitary gland. Called by Karlas "fossula hypophyseos," by Wiegand³⁷ "impressio hypophyseos," and by

Cardillo and Bossi¹¹ "fossetta pituitaria," this depression occupies an often asymmetric position at the base of the dorsum and may continue onto the floor of the sella. The curve of this structure may also be seen at times on the dorsum in the lateral view (Fig. 11), and suggests yet another possible reference point for measurement of the length of the sella.

"Bridging," the formation of bony connections between the clinoids unilaterally or bilaterally, is a relatively common finding. While these bridges do not encroach upon the cavum sellae, they are projected upon it in the lateral view, often obscuring its details and causing the sella to appear deceptively small.

The floor of the sella is sometimes represented on lateral roentgenograms by a double or a triple contour (Fig. 12) because of a slope of the floor toward one side or the other (Fig. 13, *a* and *b*). This slope may be strikingly exaggerated in pathologic cases (Fig. 13, *c*, *d* and *e*).

An important question in sellar roentgenography is the correspondence between the pituitary gland and the sella turcica (Table 1). The sella contains, in addition to the pituitary and its dural investment, connective tissue, the perihypophyseal venous plexus, and sometimes small or large subarachnoid cysts.²⁵ It has been estimated^{12, 17, 39} and others²⁵ that the pituitary itself occupies only 50-85 per cent of the cavum

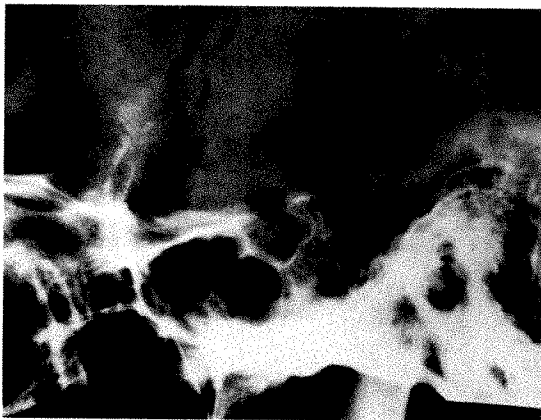


FIG. 11. Fossula hypophyseos.

sellae; our own data suggest an average figure of about 79 per cent. Probably the pituitary can increase in size mostly at the expense of venous filling, as much as doubling (as in pregnancy) without altering the bony sella. Thus considerable enlargement of the pituitary may be unobservable roentgenologically. The pituitary may even exceed the volume of the sella: we have found 2 pituitaries in 66 cases which bulged, being in excess of their sellae by 10 per cent and 18 per cent respectively. These bulging glands occurred in a 35 year old man with cirrhosis and hepatic failure, and a 13 year old nephritic boy. In neither of these patients was intracranial or endocrine pathology apparent. To date, pituitary histology is available in one of these cases (the nephritic boy) and is normal.

On the other hand, the pituitary may so far fail to fill the sella that the anatomic specimen appears empty. In 788 cases, Busch⁹ found "empty" sellae in 5.5 per cent. We have also observed "empty" sellae, one in the present series. Busch has noted that the "empty" sella is usually larger than normal, and, in fact, our case is the largest sella in our series. In such large but "empty" sellae, pneumoencephalog-

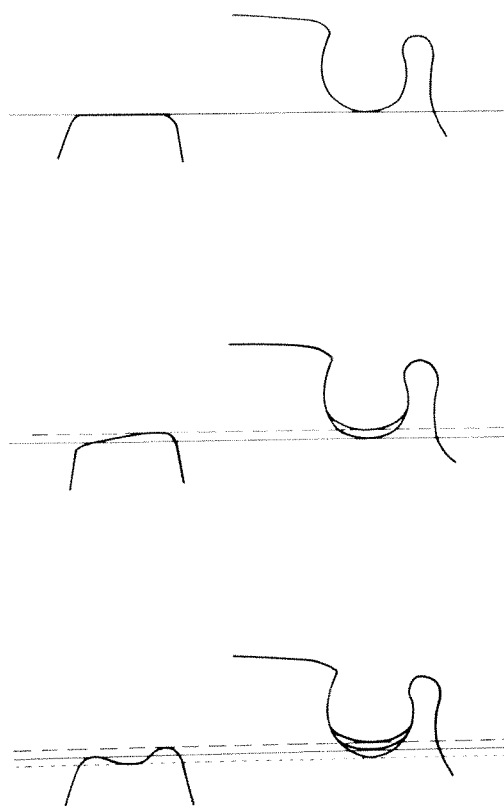


FIG. 12. Single, double, and triple contours of sellar floor in lateral views (sketches on right) and corresponding shape of floor as seen in sagittal views (sketches on left).

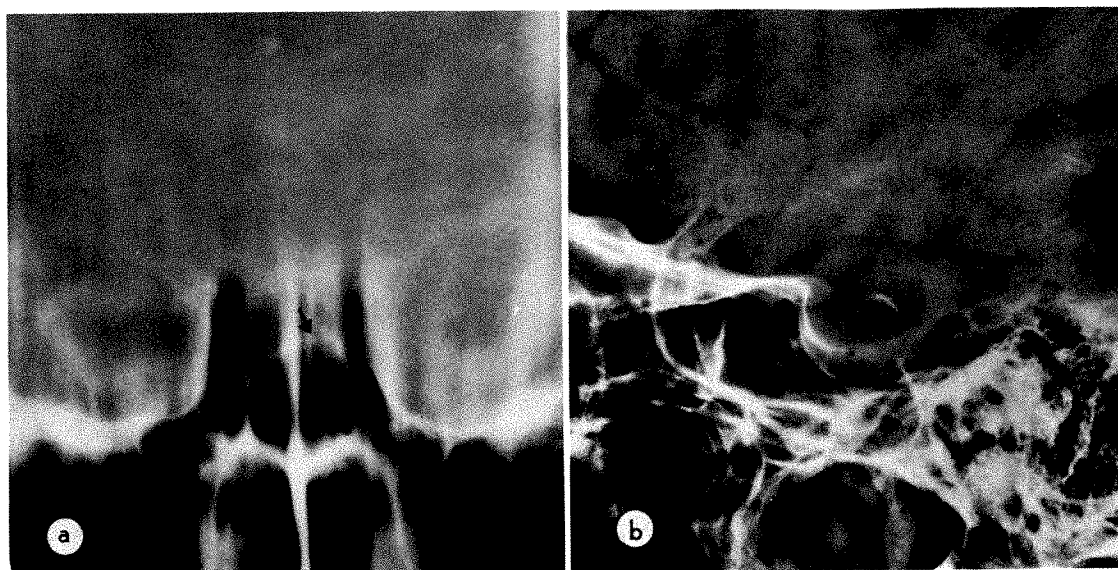


FIG. 13. (a) Slanting sellar floor and corresponding lateral view with double contour (b) in a case with no clinical evidence of intrasellar lesion.

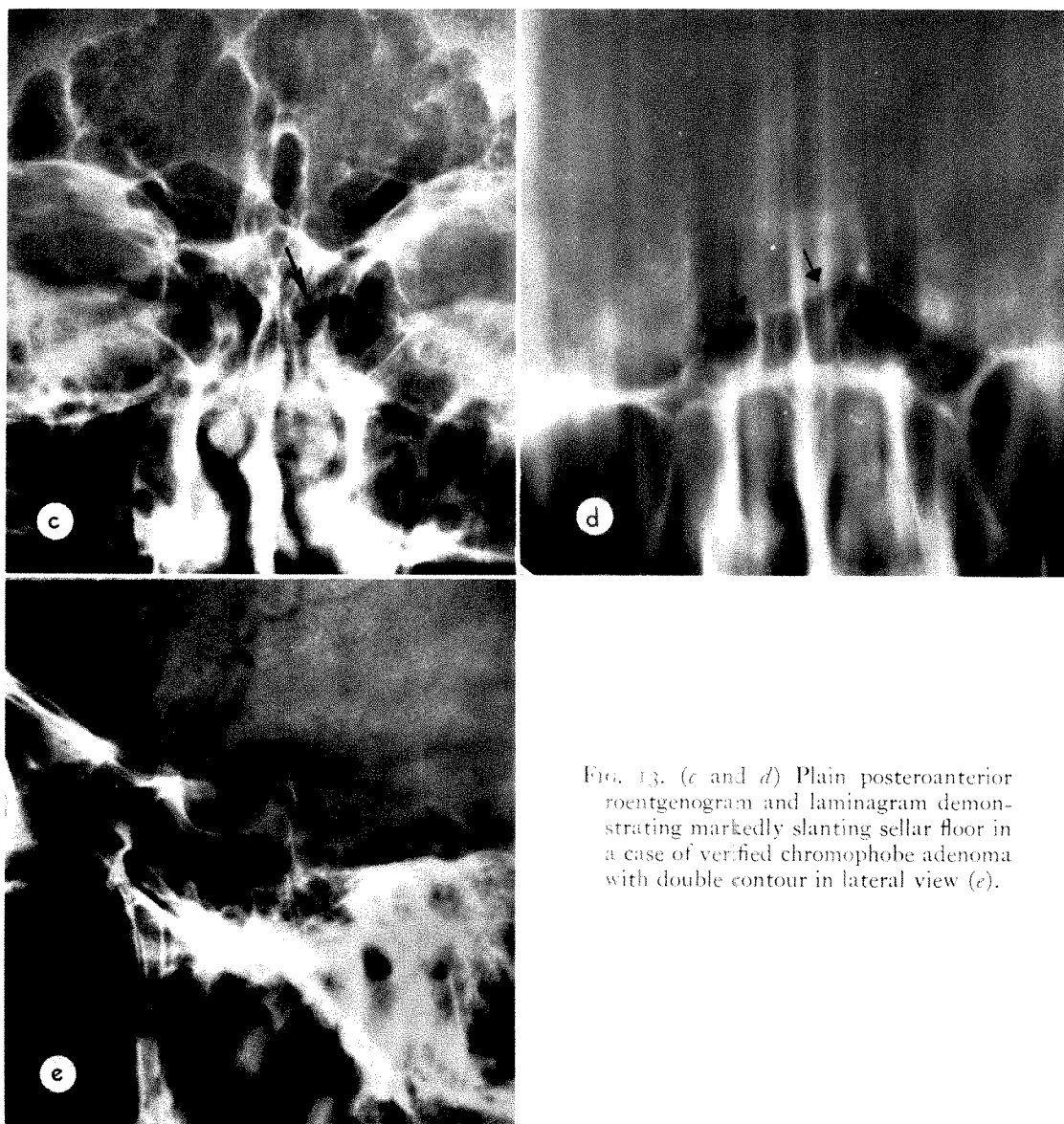


FIG. 13. (*c* and *d*) Plain posteroanterior roentgenogram and laminagram demonstrating markedly slanting sellar floor in a case of verified chromophobe adenoma with double contour in lateral view (*e*).

raphy may reveal a subarachnoid cyst extending into the sella and accounting for the discrepancy between gland and fossa.^{15,18}

It is worth emphasizing that these instances of marked disparity between the pituitary and the sella are the exception rather than the rule: Busch found a good fit in 70.5 per cent of his 788 cases, and in 19 per cent the fit was inexact but not markedly so. Again, our own experience is in agreement. Several authors^{12,50} have suggested that the effects of chronic illness, postmortem emptying of the vasculature

and autolysis may, in fact, make the difference greater in cadavers than in most living patients.

For useful measurement, a constant focus-film distance must be used, and care taken to avoid tilt or rotation of the head. Acheson¹ has discussed the estimation of error from such technical factors and from minor inconsistencies on the part of the reader.

METHODS OF ROENTGENOLOGIC MEASUREMENT

With this general background in mind,

TABLE I
SELLA TURCICA AND PITUITARY GLAND CORRELATION

Author	No.	
Hrdlicka ³⁴ (1898)		"the sella turcica is not really a perfect mold of the hypophysis, but the excess is small"
Howe ³³ (1919)		"hypophysis about fills the pituitary fossa transversely" but not in antero-posterior direction
Rasmussen ⁴⁹ (1924)		"considerable discrepancy"
Berlinger ³ (1932)	37	average pituitary = 593 mm. ³ ; average sella = 964 mm. ³
Kovács ³⁹ (1934)	15	pituitary fills 50-70% of sella
Bokelmann ⁶ (1934)	99	size of sella "permits only uncertain conclusions" as to pituitary size
Ottaviani ^{46, 47} (1938-1939)	70	average pituitary = 570 mm. ³ ; average sella = 1,230 mm. ³
Marx, Hesse, and Neumann ⁴² (1947)	90	average pituitary = 600 mm. ³ ; average sella = 950 mm. ³ ; $S = 10.3$
Carstens ¹² (1949)		pituitary fills 50-70% of sella
Busch ⁹ (1951)	788	good fit in 70.5%; inexact, 24.5%; gross difference, 5.5%
Dill ¹⁷ (1952)	106	pituitary fills 55-85% of sella, average 75%
Fazao ²⁴ (1956)	91	average pituitary = 723 mm. ³ ; average sella = 1,240 mm. ³
Mahmoud ⁴¹ (1958)	19	"the pituitary gland fills most of the sella turcica"
Eugyi ⁸ (1960)		pituitary volume (mm. ³) = $\frac{0.35}{1.25} ST$ volume (mm. ³)
Di Chiro and Nelson (1962)	62	pituitary fills an average of 79% of its sella (range 46 to 118%). Correlation 0.854. Pituitary volume = .703, cast volume + 56.287. Average adult pituitary = 608 mm. ³ ; average sella = 754 mm. ³

we may proceed to a consideration of methods for the roentgenologic measurement of the sella turcica, and indirectly of the pituitary gland. These fall essentially into 3 groups: linear, areal, and volumetric.

I. LINEAR MEASUREMENT

The selection of bony landmarks is obviously of great importance in linear measurement. For the most anterior point, various authors have used the tip of the tuberculum

sellae, the base of the tuberculum sellae, the middle clinoid process, and the most rostral point of the anterior curvature of the sella. The posterior point for the measurement of length has been taken as the most anterior point of the dorsum, the top of the dorsum, the base of the dorsum, and the most posterior point on the anterior surface of the dorsum. For depth, a perpendicular from the line used for length measurement to the deepest point of the floor, the distance from a line from the tuberculum or from the anterior clinoids to the posterior clinoids to the floor, etc., are used. This list is by no means exhaustive, and it may easily be seen why various observers have reported rather disparate values in the measurement of the normal sella.

We shall consider that the clinoids are not relevant, as they lie well lateral to the cavum sellae, upon which they are superimposed in the lateral projection. For length, we have chosen to use the greatest anteroposterior diameter in a horizontal plane (Fig. 14, left). In cases of double or triple contour of the dorsum, we measure the length to the most posterior contour observed, in agreement with Carstens,¹² as this posterior contour is the one most likely to represent the central portion of the dorsum. For depth, it has seemed sensible to set an upper limit approximating the position of the sellar diaphragm. Although the diaphragm usually originates just below the tip of the tuberculum, we have chosen for the sake of clarity to draw a line from the tip of the tuberculum to the top of the dorsum, to drop a perpendicular to this line to the deepest point in the floor, and to measure along that perpendicular (Fig. 14, left). If there are 2 contours of the floor, we measure to a midpoint between

them. In the presence of 3 contours, we measure to the middle contour. This probably gives the best approximation of the central portion of the floor. For the measurement of the width of the floor, the distance between the 2 highest points located on the edges of the plateau is used (Fig. 14, right). Even such an apparently straightforward approach does not avoid all ambiguities, but it is a useful guide in the majority of cases.

2. AREAL MEASUREMENT

In 1925, Haas²⁹ introduced a method for the determination of the area of the sellar profile: the sellar outline is traced on transparent paper or glass, and the tracing superimposed upon millimeter-ruled paper. The number of millimeter squares lying within the limits of the sella is then counted. Use of a planimeter was introduced by Karlin.³⁵ Hare, Silveus, and Smedal³² have used comparison of the given sella with a number of standard tracings, their "sellameter." In each case, a definition of the upper border of the sella must be decided upon by the investigator, and a selection made from among the several posterior contours mentioned above. It has been maintained that the method of area determination is more accurate than that of measuring the 2 linear dimensions, that cases which fall within the limits of normal by linear measurements can be shown to be enlarged by the method of area measurement, and that the area provides a more reliable basis for the comparison of the sella of a given patient from one examination to the next.³⁵ A weak correlation between the area of the sellar profile and the volume of the sella has been noted by Kovács,³⁹ Marx, Hesse and Neumann,⁴² and Tori.⁵⁴ Mossberg,⁴⁵ in 27 children, found the logarithm of the volume of the sella to be linearly related to the area. The error in area measurement is said to be 6-8 per cent.⁵⁰

Area measurement, just as linear measurement of the lateral profile, considers only 2 dimensions.



FIG. 14. Measurement of length, depth, and width of sella.

TABLE II
ROENTGENOGRAPHIC CALCULATION OF VOLUME OF SELLA (mm.³) IN ADULTS

	Cast			$V =$	Roentgenographic			No.	Error
	No.	Ave.	Range		No.	Ave.	Range		
Meldolesi and Pansadoro ⁴¹	12	985	411-1,314	area $\times$ dorsum	34	985	561-1,410	12	10.4
Cardillo and Bossi ¹¹	17	911	270-1,216	(area—5%) $\times$ (dorsum—10%)	15	960	345-1,804	15	12.5
				(area—5%) $\times$ (laminagraphic diameter of floor—11.5%)	17	889	263-1,729	17	5.1
Di Chiro and Nelson	48	754	489-1,229	$1/2(L \times H \times W)$	49	654	450-1,092	46	16.9

3. VOLUMETRIC MEASUREMENT

Meldolesi and Pansadoro⁴¹ (Table II) were the earliest workers to calculate the volume of the sella turcica from roentgenographic data. They proposed that the area of the sellar profile be multiplied by the narrowest width of the dorsum sellae as seen in half-axial views. These authors studied 17 normal adults and 3 adult patients with muscular dystrophy. Volumes of 411 to 1,314 mm.³ were found, with an average of 985 mm.³. Calculated volumes in 34 adults ranged from 561 to 1,414 mm.³, with an average of 985 mm.³. In 12 cases they made casts of the sella turcica and compared the volume of the casts with the predicted volume by roentgenographic estimation; the average error in these 12 cases was 10.4 per cent.

Vallebona and Conte⁵⁶ suggested using the area multiplied by the transverse diameter of the sella as obtained by laminagraphy. They presented no data to test their formulation.

Cardillo and Bossi¹¹ used the technique of Meldolesi and Pansadoro⁴¹ but subtracted 5 per cent from the area and 10 per cent from the diameter of the dorsum. They compared the value thus obtained with casts of the sella and with the results of their own method, which was the multiplication of the area minus 5 per cent by the transverse diameter of the floor of the

sella as revealed by laminagraphy minus 11.5 per cent. They found an error of 12.5 per cent using their modification of the Meldolesi-Pansadoro method, and an error of 5.1 per cent with their own technique.

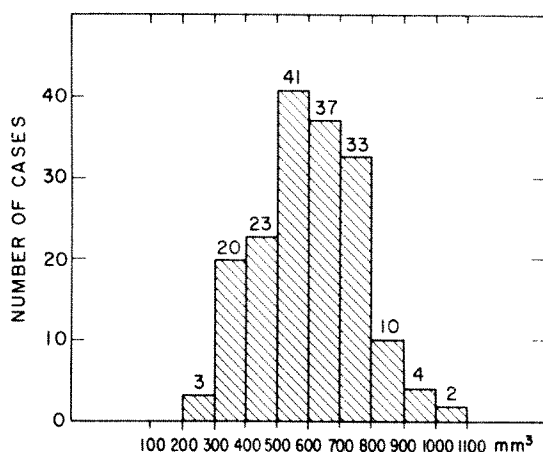
Di Chiro¹⁴ has proposed a method for the estimation of the volume of the sella turcica based upon the formula for an ellipsoid,

$$V = (4\pi/3) \times \frac{L}{2} \times \frac{H}{2} \times \frac{W}{2},$$

where L is length, H height, and W width. Factors for magnification error and the empirical error found in a small series of 15 cases were included, and the following formula was evolved: $V = 1/2 (L \times H \times W)$. The roentgenographic volume of the sella as estimated by this method ranged from 233 to 1,092 mm.³ in 173 normal adults (Graph III).

CLINICAL EVALUATION OF DI CHIRO'S METHOD

In order to be clinically useful in the common problem of the questionably abnormal sella, a method of evaluation should be both accurate and simple of execution. Methods requiring determination of the area of the sella and those requiring laminagraphy, while not conceptually complex, demand time and equipment not available in every radiologic department. It was felt



GRAPH III. Roentgenographic volume of sella in 173 normal adults (36 inches focal distance).

that Di Chiro's method fulfilled the criterion of ease of execution; it was in an attempt to evaluate the method with regard to accuracy that the following roentgenographic-anatomic comparison was undertaken.

Our technique was as follows: roentgenograms were taken in the lateral and anteroposterior positions on fresh cadavers free of pituitary gland pathology, if such roentgenograms had not been taken during the individual's life. The bony block containing the sella turcica was then removed from the base of the skull with the pituitary gland *in situ*. The pituitary gland was either removed before preservation, or the entire block was placed immediately in 10 per cent formalin, it having been found that fixation in 10 per cent formalin did not produce significant shrinkage. The pituitary gland, fresh or preserved, was dissected with great care from the sella turcica and removed with its capsule, an attempt being made to preserve the walls of the cavernous sinus. The pituitary gland was then weighed and its volume determined by displacement of distilled water. The volume of the sella turcica was studied by filling it with dentist's wax, which has favorable qualities of specific gravity, cohesiveness, and malleability with increased temperature. The superior surface of the cast was taken to be the plane of the

diaphragma sellae. Reconstruction of the lateral boundaries was more difficult, and a certain element of arbitrariness was felt to be inevitable. The attempt was made to make these lateral boundaries perpendicular to the lateral margins of the floor of the sella.

Karlas has estimated the error in volume determination to be "a good 10 per cent of the average figure," chiefly because of the difficulty in assigning lateral and superior boundaries. In the opinion of the present authors, as determined from several casts of a given sella, the error is probably closer to 20 per cent.

Three values were thus obtained: the roentgenographic estimation of the volume of the sella, the volume of the pituitary gland and the volume of the sella itself.

A total of 60 cases was fully studied. Of these, 31 were male, 29 female. The ages ranged from 3 to 86 years; the average age was 35, with 67 per cent between the ages of 20 and 60 years. Fourteen individuals were 16 years old or younger, and data from them were of course excluded from the adult averages, but were utilized in the correlations of roentgenographic and anatomic values. In an additional 6 cases, 2 of the 3 values were available and were used in the statistical evaluations where appropriate.

In adults, we found the roentgenographic predictions of sellar volume to average 654 mm.³, and range from 450 to 1,092 mm.³ (Table II). The average pituitary gland volume of the adult was 608 mm.³, with a range from 400 to 945 mm.³ (Table III). The average sellar volume as measured from casts was 754 mm.³, with a range from 489 to 1,229 mm.³ (Table IV).

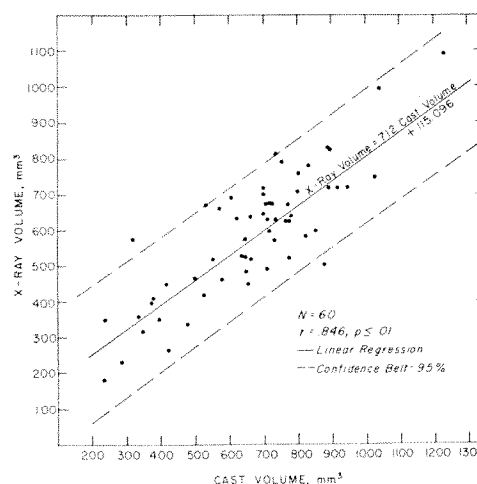
If the third dimension were constant, it would be reasonable to anticipate that a large sella in the lateral projection would be found to have a large volume. However, the correlation has proved surprisingly low. Using area as a measure of the size of the sella in the lateral view, Marx, Hesse, and Neumann⁴² found a variability of 43.4, and Tori⁵⁴ found that for the small sella the

TABLE III
ANATOMIC VOLUME OF PITUITARY GLAND (mm.³) IN ADULTS

Author	No.	Average						Range
Lucien ⁴⁰ (1911)	Not specified for adults	Age of pt.	Volume of pit.	30	500	60	610	400-1,030
				35	510	65	640	
				40	700	70	630	
				45	650	75	640	
		20	470	50	350	80	440	
		25	540	55	600			
Berblinger ³ (1932)	37	593						300- 900
Bokelmann ⁶ (1934)	99	♂ 421 ♀ 510						160- 840
Ottaviani ⁴⁷ (1939)	70	570						300-1,300
Busch ⁹ (1951)	243	660						240-1,230
Dill ¹⁷ (1952)	106	570						310- 990
Di Chiro and Nelson (1962)	51	608						400- 945

correlation was 0.0958, for the medium 0.3469, for the large sella 0.0626. Karlas³⁷ compared the area of the mid-section of the anatomic specimen with the volume, and found a correlation of 0.54. The failure of the lateral projection to provide a good prediction of sellar volume is probably due in large measure to the neglect of the transverse diameter, as suggested earlier. When this factor is included, more accurate prediction is in fact possible. Our data show that a correlation between the volume of the cast of the sella turcica and the volume as estimated roentgenographically was 0.846 (0.719 in adults, 0.594 in children), a figure significant at the 1 per cent level. Graphic representation of this correlation, with confidence belt, is presented (Graph IV). The discrepancy between cast and roentgenographic volume in each case averaged 19 per cent of the cast volume (17 per cent in adults, 24 per cent in children), with a range of zero to 83 per

cent. In 90 per cent of cases, this value lay between zero and 32 per cent. In 38 of 46 adults, the roentgenographic volume was smaller than that of the cast.



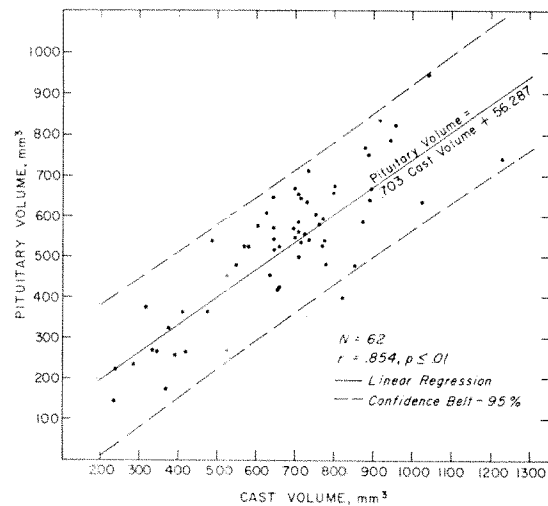
GRAPH IV. Relationship between roentgenographic volume of sella and observed volume of sellar cast in 60 cases.

TABLE IV
ANATOMIC VOLUME OF SELLA TURCICA (mm.³) IN ADULTS

Author	No.	Average	Range
Goldfarb ²⁸ (1918)	24	768	469-1,226
Berblinger ³ (1932)	37	964	500-1,400
Casazzo ¹³ (1932)	362	1,292-1,778	
Bokelmann ⁶ (1934)	99	1,264	640-2,420
Meldolesi and Pansadoro ⁴⁴ (1937)	12	985	411-1,314
Ottaviani ⁴⁷ (1939)	70	1,230	750-2,000
Kadanoff ³⁶ (1939)	119	890	530-1,670
Cardillo and Bossi ¹¹ (1941)	17	911	270-1,216
Marx, Hesse, and Neumann ⁴² (1947)	90	950	520-1,740
Karlas ³⁷ (1948)	171	939	455-1,750
Busch ⁹ (1951)	243	approx. 890	450-1,530
Dill ¹⁷ (1952)	106	869	521-1,780
Tori ³⁴ (1953)	429	763-875	400-1,500
Frazao ²⁴ (1956)	91	approx. 1,240	of averages 920-1,620
Di Chiro and Nelson (1962)	48	754	489-1,229

The pituitary gland was found to fill an average of 79 per cent of its sella (81 per cent in adults, 76 per cent in children). The range, including the 2 bulging pituitary glands, was 47 to 118 per cent and in 90 per cent of cases this value was between 63 and 100 per cent. The discrepancy between the pituitary and the sella averaged 22 per cent (20 per cent in adults, 27 per cent in children), with a range from zero to 53 per cent. In 90 per cent of the cases it lay between zero and 38 per cent. The correlation between the pituitary and the sella was 0.854 (0.646 for adults, 0.818 for children), again significant at the 1 per cent level (Graph v).

Discrepancy between pituitary volume and roentgenographic estimation of volume was 16 per cent of the pituitary gland

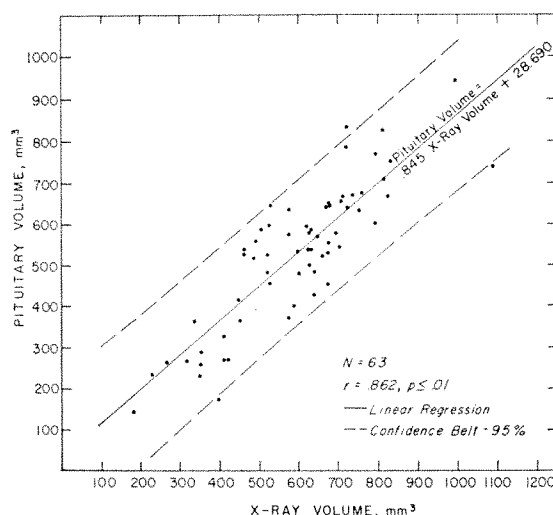


GRAPH V. Relationship between volume of pituitary and volume of sellar cast in 62 cases.

volume (12 per cent in adults, 28 per cent in children). This is in fairly good agreement with the 18 per cent discrepancy found in 10 cases reported earlier by Di Chiro.¹⁴ The range was 1 to 103 per cent, with 90 per cent of cases between 1 and 28 per cent. The correlation coefficient was 0.862 (0.720 in adults, 0.758 in children), significant at the 1 per cent level (Graph VI). In 49 of 63 cases, the roentgenographic volume was larger than the pituitary volume.

If these data are representative, knowledge of the 3 linear dimensions of the sella should permit an estimate of pituitary size which will deviate from the directly measured volume of the excised pituitary by an average of 16 per cent of the volume of the pituitary. An estimate of sellar volume can be made which will deviate from the observed volume by 19 per cent. Stated differently, the pituitary size can be measured with an average accuracy of 84 per cent and the sellar volume with an average accuracy of 81 per cent. In each case, estimates for adults were found to be more accurate than for children. If only adults are considered, average accuracies are 88 per cent for pituitary size and 83 per cent for sellar volume. Each prediction can be made with the expectation that 90 per cent of cases will be accurate within approximately 30 per cent, and 95 per cent of cases may be expected to fall within the confidence belts shown in Graphs IV and VI. This range of error is probably a tolerable one in clinical practice, particularly as sellar pathology, when symptomatic, will usually have produced a greater degree of sellar enlargement than encompassed by this margin. A certain "no man's land" of borderline values will inevitably be found, as with most clinical tests.

It may be somewhat surprising that a formula based upon sellar measurements should yield a value smaller than that of the sella turcica but larger than that of the pituitary gland in a majority of cases, and slightly nearer to the pituitary gland volume than to the volume of the sella.



GRAPH VI. Relationship between pituitary volume and roentgenographic volume in 63 cases.

This may be related to the fact that the formula for an ellipsoid was used. While most sellae are essentially ellipsoidal, some are rectangular. The pituitary gland is more regularly ellipsoidal, and if the pituitary filled the sella at the center of each diameter, but did not fill the "corners" of the occasional rectangular sella, such an average result might be anticipated. The use of a formula for sellar volume based upon the volume of the rectangle proves less accurate than the one employed here, as the majority of sellae are indeed ellipsoidal.

Comparison of this method with the methods of Meldolesi and Pansadoro,⁴⁴ and of Cardillo and Bossi,¹¹ would certainly suggest that greater accuracy may be attained with the latter techniques (Table II). We have not attempted to use the methods applied by these authors in their small series. Measurement of the dorsum, as required in the Meldolesi-Pansadoro method, is not possible without special techniques in more than half of cases, and the Cardillo-Bossi method requires frontal laminagraphy. While neither laminagraphy nor consistent projection of the dorsum into the foramen magnum is a particularly difficult procedure, both require time, additional exposure of the patient to radiation, and the use of equipment

not universally available. The method of Di Chiro has the advantage of applicability in routine clinical radiology.

SUMMARY

It is common practice to estimate the size of the sella turcica from the lateral roentgenogram alone. Limitations of this 2-dimensional approach are discussed, and the importance of consideration of the transverse diameter (width) is emphasized. Evaluation of sellar width may be made by measurement of: (1) the width of the dorsum at its narrowest point ("waist") as seen in half-axial projections, (2) the floor of the sella on straight posteroanterior or anteroposterior roentgenograms, or in doubtful cases on coronal laminagrams, and (3) the anterior and (4) posterior walls of the sella as seen in submentovertical projections. Because of the ease and reliability of demonstration of the sellar floor in straight sagittal views of the skull, this method is recommended for routine use.

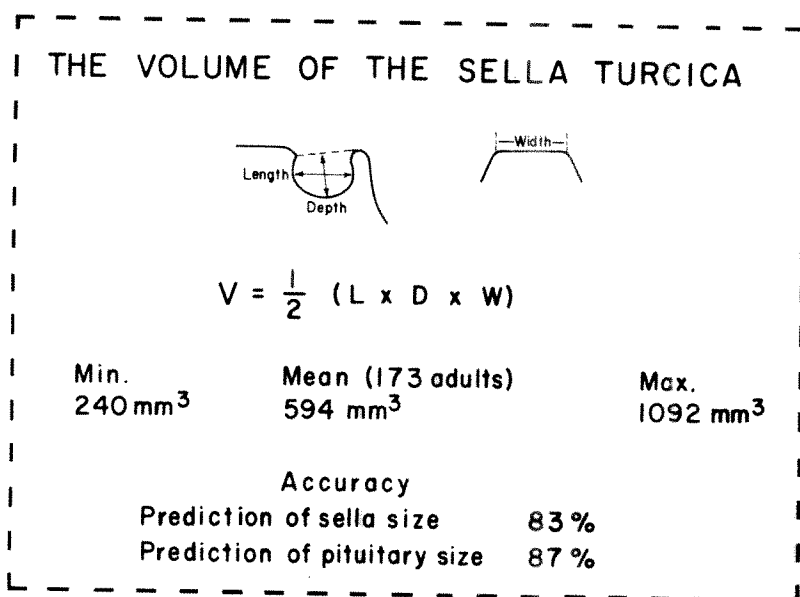
It is pointed out that the length as well as the width of the sella can often be measured in submentovertical projections, and that the pathologic sella may show

changes in this view as well as in the anteroposterior, posteroanterior and lateral views.

The techniques of actual measurement of the sella turcica are discussed, and the most satisfactory method, in the authors' opinion, is detailed.

The method previously proposed by Di Chiro for estimation of the volume of the sella is evaluated in 66 cases, with roentgenographic and anatomic comparisons. Knowing the 3 linear dimensions of the sella which can in most cases be obtained from routine lateral and posteroanterior roentgenograms, it is possible to state pituitary gland size with an average error of 16 per cent and sellar volume with an average error of 19 per cent. If only adults are considered, the errors are 12 per cent and 17 per cent respectively. Ninety per cent of cases will be accurate within approximately 30 per cent. It is felt that this range of error is probably acceptable for most clinical purposes.

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Facsimiles of this chart on transparent plastic may be obtained upon request from: Section on Neuroradiology, NINDB, NIH, Bethesda 14, Maryland.

The possibility of visualizing the anterior aspect of the dorsum in the submentovertical projection was suggested by Mr. Joseph Morel, Chief X-ray Technician at the Clinical Center, National Institutes of Health, Bethesda, Maryland. Mrs. Carolyn Kline did the secretarial work. The statistical evaluations were performed by Mrs. Doris Sadowsky.

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ROENTGEN DIAGNOSIS OF BLOW-OUT FRACTURES OF THE ORBIT*

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BLOW-OUT fracture of the orbit is a fracture of the orbital floor caused by a sudden traumatic increase in intra-orbital pressure. This type of fracture is usually associated with herniation of orbital bone fragments and soft tissues into the subjacent maxillary sinus.

Reports of fractures of the orbital floor are relatively uncommon in the medical literature despite the increase in the number of patients with this type of injury. Fractures of the orbital floor have been described mainly in the ophthalmologic and plastic surgical literature and, to a lesser extent, in the radiologic literature.

In 1899, Lang⁶ suggested that every case of traumatic enophthalmos was secondary to a fracture of the orbital floor. Supporting this is a review of 120 cases of facial fractures involving the orbit made by Pfeiffer¹⁰ in 1941. He observed that 53 patients developed enophthalmos after the injury. In many of these cases the fracture was obvious clinically and roentgenographically. In 24 cases, where the fracture involved the posterior orbital floor but did not break the orbital rim, the diagnosis was established by means of roentgenograms alone.

In 1940, Culler⁴ indicated the advantages of laminagraphy of the orbit. McGrigor and Samuel,⁸ in 1945, described the roentgen diagnosis of fracture of the orbital floor in the absence of fracture of the orbital rim in patients with diplopia.

Converse, Smith, and others,^{1,2,3,11,12} in a series of papers published between 1944 and 1960, reported on the treatment of traumatic enophthalmos and diplopia following fractures of the orbital floor. These authors described the blow-out fracture

syndrome and discussed its causation. Smith and Regan¹² produced a blow-out fracture in a cadaver by striking the orbit with a hurling ball.

Duke-Elder,⁵ in the Textbook of Ophthalmology, has a good description of fractures of the orbital floor. This type of fracture is not dealt with in most textbooks of roentgen diagnosis. One case is described by Young¹³ in "Skull, Sinuses and Mastoids." More recently, the roentgen diagnosis of blow-out fracture of the orbital floor was described by Lewin, Rhodes, and Pavsek⁷ and 3 cases were reported.

ROENTGEN DIAGNOSIS

A diagnosis of blow-out fracture of the orbit by roentgenograms is frequently missed if the roentgenologic examination is not comprehensive. Fracture lines may be mistaken for superimposed bony septa or suture lines, or be hidden by disease processes in the underlying maxillary sinus. The thin orbital floor, partially transparent on roentgenograms, may be obscured against the background of other bones of the skull.

The common signs of blow-out fracture of the orbit are: (1) fragmentation of the bone of the orbital floor; (2) depression of bony fragments; and (3) prolapse into the subjacent maxillary sinus of orbital soft tissue. Associated roentgen findings may be: (1) fracture of the inferior orbital rim; (2) fracture of the medial orbital wall, indicated by extension of the orbital soft tissue shadow into the plane of the ethmoid cells; (3) opacification of the underlying maxillary sinus by hemorrhage; and (4) emphysema of the orbit due to entrance of

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air through a fractured common bony wall between the orbit and adjacent sinus⁹ (See Case v, Fig. 7, *A* and *B*).

A fractured orbital floor is seen as a depressed, regular or irregular, horizontal or curvilinear bone density superimposed to a variable extent on the upper half of the maxillary sinus (See Case iv, Fig. 6).

Depressed bony fragments of the orbital floor usually can be demonstrated on the Waters' view of the maxillary sinuses and orbits as white bony lines, if the edges of the fragments are parallel to the roentgen-ray beam. When bony fragments are superimposed on each other and not exactly parallel to the beam, they will cause a plane of gray density on the roentgenogram.

Thin bony fragments in a plane of 90° to the roentgen ray will not be visible on roentgenograms. The roentgen diagnosis will then depend entirely on the demonstration of prolapsed orbital soft tissue profiled by air in the subjacent maxillary sinus. This herniated soft tissue is seen as an opaque gray to white soft tissue density on the roentgenogram (See Case vii, Fig. 9). If the herniated soft tissue is orbital fat, its appearance may simulate a small transparent cyst in the upper half of the antrum (See Case viii, Fig. 10, *A* and *B*).

The stereoscopic or nonstereoscopic Waters' posteroanterior projection (or slight modifications of it) for visualizing the orbits, maxillary sinuses and facial bones is most useful for demonstrating blow-out fracture.

The Caldwell posteroanterior projection of the orbits may reveal the downward displacement of the orbital floor. In the Caldwell projection, however, fracture of the orbital floor is usually obscured by superimposition of the petrous pyramid over the lower portion of the orbit and the upper portion of the antrum.

Depressed fracture of the orbital floor and prolapse of the orbital soft tissues into the maxillary sinus may not be detectable by roentgen examination if the sinus is completely opaque from hemorrhage associated with fracture, or from pre-existing

sinus disease. Under these circumstances the herniated orbital soft tissues are not profiled because of the lack of air in the sinus for adequate contrast (See Case xiii, Fig. 15). Visualization is facilitated by evacuation of blood and the introduction of air into the maxillary sinus (See Case xiv, Fig. 16, *A* and *B*).

Anteroposterior or posteroanterior laminagrams of the orbits and maxillary sinuses may demonstrate fractures of the orbital floor with greater clarity than the routine Waters' view (See Case ix, Fig. 11, *A* and *B*). Laminagrams are done at 0.5 to 1 cm. intervals from the anterior to the posterior limits of the orbits and antra. By this method fractures at different levels of the orbital floor may be demonstrated even when the diagnosis on routine Waters' projection is difficult to determine.

In the late post-traumatic phase, roentgen diagnosis is usually facilitated because of subsidence of soft tissue edema and hemorrhage and return of air in the maxillary sinus. Air is an excellent contrast medium for profiling herniated orbital soft tissues and bone fragments.

ANATOMY OF THE ORBIT

The orbital contents are protected anteriorly by a strong rounded rim of bone, the superior orbital arch of the frontal bone above, the zygoma laterally, the frontal process of the maxilla medially, and inferiorly by the relatively thick rim of the orbital floor, formed by the zygoma and maxilla (Fig. 1). Situated between the two strong bony abutments, the zygoma and frontal process of the maxilla, the inferior orbital rim is supported from below by relatively thin bone which constitutes the anterior wall of the maxillary sinus. The posterior half of the orbital floor is an area of thin bone which separates the orbital cavity from the maxillary sinus. This thin portion of the orbital floor is weakened further by an infra-orbital groove or canal. The orbital walls are thin in two additional areas over the temporal fossa, laterally, and in the lamina papyracea and orbital

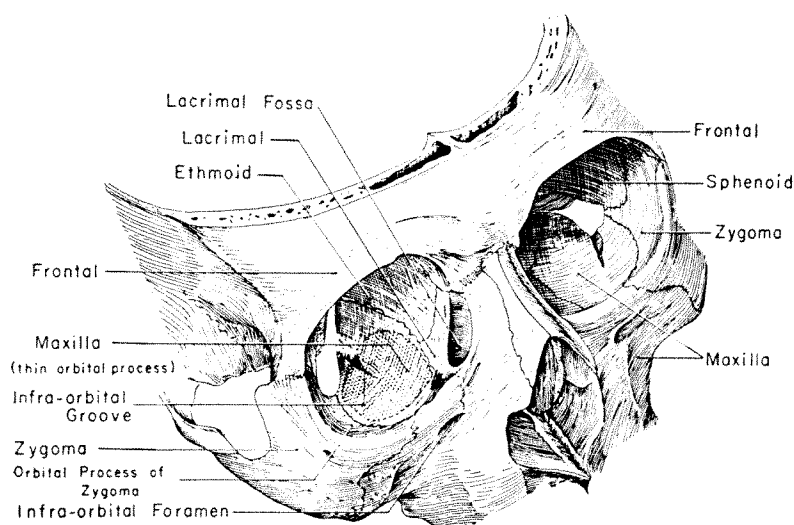


FIG. 1. Diagram showing the anatomy of the bony orbit.
(Reproduced with permission of *British J. Plast. Surg.*²)

plate of the ethmoid, medially. These thin areas are readily demonstrated by transillumination of the dried skull.

MECHANISM OF BLOW-OUT FRACTURE OF THE ORBIT

Blow-out fractures result from sudden increase of intra-orbital pressure, secondary to a blow to the eye and soft tissues of the orbit from a convex object of greater diameter than the orbit (Fig. 2). The orbital soft tissues are suddenly compressed and the increased pressure is transmitted to the bony orbital wall. Since the thin floor of the orbit posterior to the eyeball is slightly elevated, it receives the greatest impact from traumatic increase of intra-orbital pressure. Consequently, the floor is the usual site of fracture. Bony fragments and orbital soft tissues are displaced downward into the underlying maxillary sinus. This may be accompanied by hemorrhage. Occasionally, the blow-out fracture will involve the medial orbital wall in the area of the lamina papyracea and the orbital plate

of the ethmoid. Medial displacement of bony fragments and orbital soft tissues will be accompanied by local hemorrhage and edema in the plane of the ethmoid cells.

CLINICAL SIGNS OF BLOW-OUT FRACTURES OF THE ORBIT

Enophthalmos, downward displacement of the eyeball, impaired upward rotation of

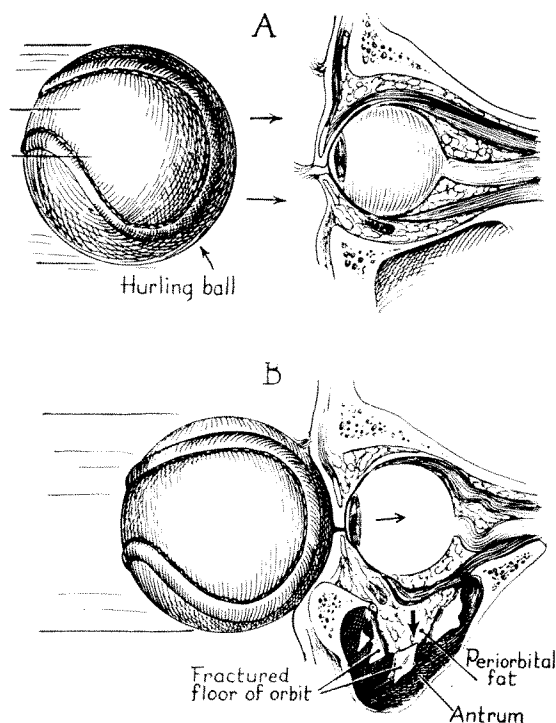


FIG. 2. Diagram showing how a blow to (A) the soft tissues of the orbit causes (B) a blow-out fracture of the orbital floor with prolapse of bone fragments and soft tissues, and incarceration of the inferior oblique and inferior rectus muscles. (Reproduced with permission of *Am. J. Ophthalm.*¹²)

the eyeball, diplopia, and sensory disturbances of the skin supplied by the infra-orbital nerve are the most important clinical manifestations of blow-out fracture.

Enophthalmos appears after resorption of hematoma and subsidence of edema. Enophthalmos of long standing is particularly difficult to correct because of atrophy of the intra-orbital soft tissues.

Traumatic enophthalmos results from both a relative and an actual enlargement of the orbital cavity. The orbital fat contained in a larger orbital cavity is not sufficient to maintain the normal position of the eyeball.⁶ In addition, scar tissue, as well as herniation and incarceration of orbital tissues between the depressed bony fragments, may pull the orbital contents posteriorly and inferiorly.

Impairment of motility of the eyeball, resulting in diplopia, may be secondary to: (1) direct trauma to the inferior rectus and inferior oblique muscles, or incarceration of these muscles by scar tissue, (2) herniation of the orbital soft tissues, or (3) nerve injury.

TREATMENT

A blow-out fracture may be treated by an infra-orbital or a transantral approach.

With the infra-orbital approach an incision is made in the skin exposing the infra-orbital rim. The periosteum of the orbital floor is elevated and the fracture reduced. Some type of support is then used. An autogenous bone graft is the safest and best support, but various synthetic supports may be used instead. The danger of a synthetic support is the same as that presented by any buried foreign body. Hence, such support should only be resorted to when absolutely necessary.

The transantral approach involves making a window in the anterior wall of the maxillary sinus above the canine fossa. The fracture is then supported with packing or a balloon, either of which is left in place for at least 2 weeks.

It is often necessary to employ both the infra-orbital and the transantral approaches

on one patient. When using either technique it is necessary to avoid injury to the nerves of the teeth, the infra-orbital nerve, and the ocular muscles.

REPORT OF CASES

CASE I. Fig. 3. Y.H., a 31 year old female, was struck in the right orbit 4 weeks prior to admission. The presenting complaint was diplopia. The fracture site was approached infra-orbitally and found to extend anteriorly to within 1.5 cm. of the inferior orbital rim. The orbital contents incarcerated in the fractured orbital floor were released by traction and elevation. An iliac bone graft was used to cover the defect. Recovery was uneventful.

Roentgen Findings: October 18, 1960. On the Waters' view, a moderate opacification of the right antrum was noted. There was a transverse bone fragment in the upper medial third of the antrum associated with a rounded soft tissue mass. The impression was that of a blow-out fracture of the floor of the right orbit.

CASE II. Fig. 4. D.M., an 11 year old white boy, fell and suffered a blow to the right orbit 3 days prior to admission. The presenting complaint was diplopia. The fracture site was visualized by a transantral approach, reduced, and maintained in its reduced position by aureomycin packing, which was removed from the antrum 2 weeks later. Recovery was uneventful.

Roentgen Findings: February 19, 1958. The erect Waters' view revealed depression of the right orbital floor and soft tissues in the plane of the upper antrum.

CASE III. Fig. 5, A and B. G.F., a 24 year old white male, was struck in the left eye. The presenting complaint was enophthalmos. Approach to the fracture was infra-orbital. The prolapsed orbital contents were reduced. Further approach to the fracture site was made through a transantral incision. Reduction was completed and an iliac bone graft was used to stabilize the floor of the orbit. The maxillary sinus was filled with aureomycin nasal packing which was removed 2 weeks after the operation. Recovery was uneventful. The enophthalmos was corrected.

Roentgen Findings: April 2, 1959. The erect Waters' view and supine laminagram revealed a broad, rounded prolapse of orbital soft tissues into the upper half of the left antrum through a fracture of the orbital floor.

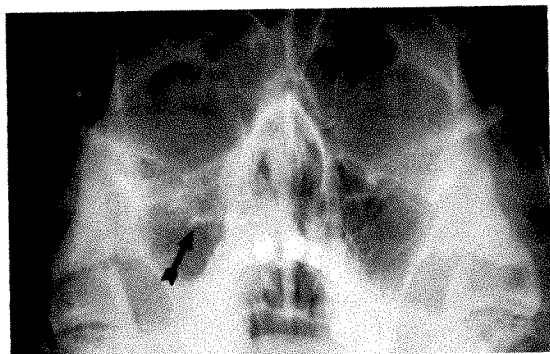


FIG. 3. Case I. Waters' view showing moderate opacification of the right antrum and a transverse bone fragment in the upper medial third of the antrum associated with a rounded soft tissue mass.

CASE IV. Fig. 6. B.G., a 38 year old Negro female, was struck in the left eye with a fist 4 weeks prior to admission. The chief complaints were discomfort and diplopia. The fracture site was explored through the maxillary sinus by means of the Caldwell-Luc approach and an incision through the eyelid along the inferior orbital margin. The fracture was reduced and it maintained reduction without support. The patient recovered most of her ocular rotation and the field of diplopia was decreased.

Roentgen Findings: January 13, 1961. The erect Waters' view demonstrated fragmentation of the floor of the left orbit with prolapse of orbital soft tissues into the upper third of the antrum.

CASE V. Fig. 7, *A* and *B*. J.S., a 57 year old



FIG. 4. Case II. Waters' view showing depression of the right orbital floor and soft tissues in the plane of the upper antrum.

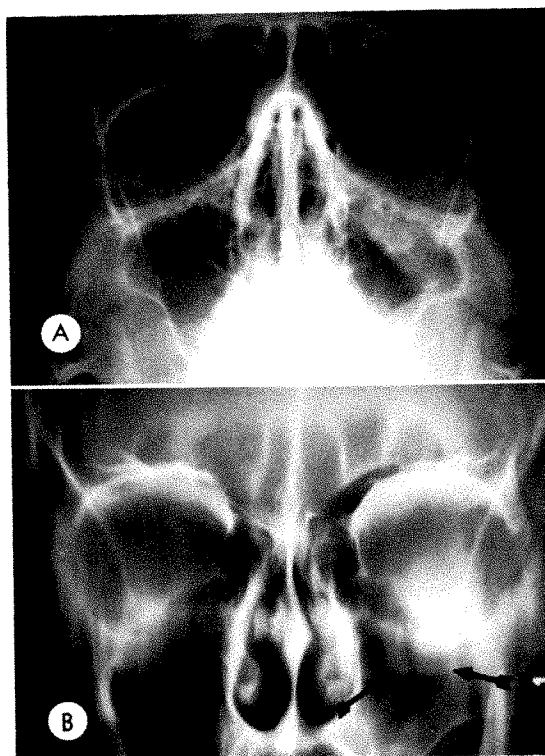


FIG. 5. Case III. (A) Waters' view and (B) lamina-gram show a broad, rounded prolapse of orbital soft tissues into the upper half of the left antrum through a fracture of the orbital floor.

Negro male, was struck in the left eye with a fist 5 days prior to admission. The chief complaints were diplopia and pain due to chemosis, emphysema, and hematoma. The fracture was approached infra-orbitally and the continuity of the floor was re-established with an iliac bone graft. Recovery was complete.

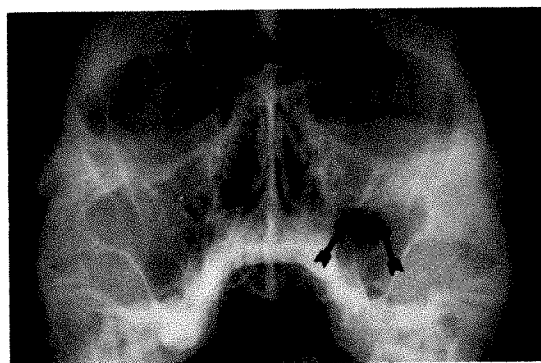


FIG. 6. Case IV. Waters' view shows fragmentation of the floor of the left orbit with prolapse of the orbital soft tissues into the upper third of the antrum.

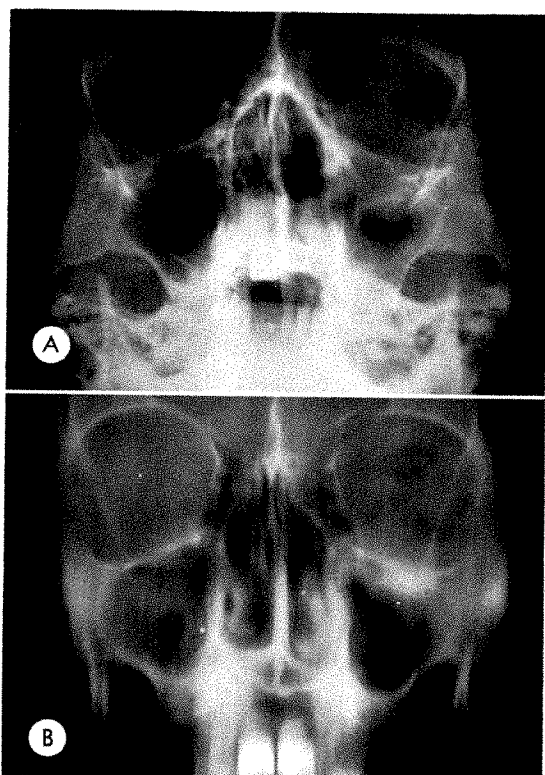


FIG. 7. Case v. (A) Waters' view shows emphysema of the left orbit and herniation of orbital soft tissues. (B) Laminagram confirms presence of a blow-out fracture.

Roentgen Findings: April 11, 1959. The erect Waters' view revealed emphysema of the left orbit and herniation of orbital soft tissues through a fractured orbital floor into the upper half of the antrum. Polypoid thickening of the sinus membrane was suggested on the upright

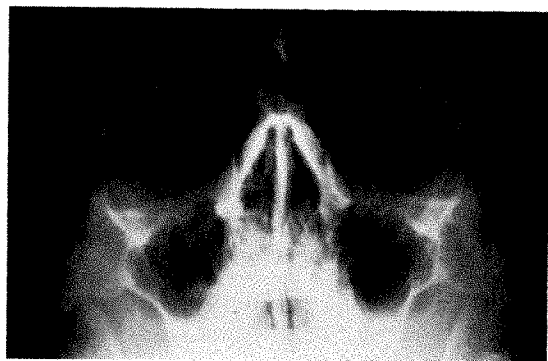


FIG. 8. Case vi. Waters' view shows small cyst-like, transparent soft-tissue mass in the upper medial angle of the right antrum and an oblique bone fragment of the floor of the orbit.

Waters' view. A supine laminagram confirmed the presence of a blow-out fracture of the orbital floor. The disappearance of apparent soft-tissue thickening along medial, lateral and inferior borders of the antrum on the supine laminagram indicated that the finding on the erect Waters' view represented submucosal hemorrhage.

CASE VI. Fig. 8. J.H., a 16 year old white male, was struck in the right eye with an elbow 1 month prior to admission. His chief complaint was diplopia with limitation of ocular rotation. Utilizing a transantral approach, the fracture was visualized and reduced digitally. The integrity of the floor was maintained with an antral pack of aureomycin gauze which was left in place for 14 days. Recovery was complete. There was no residual diplopia.

Roentgen Findings: March 1, 1961. The erect Waters' view revealed a small, cyst-like, transparent soft-tissue mass in the upper medial angle of the right antrum and an oblique bone fragment of the floor of the orbit.

CASE VII. Fig. 9. A.D., a 62 year old white female, fell on the sidewalk and struck her right eye on the evening prior to admission. The chief complaint was diplopia. The fracture site was explored transantrally. A bomb-bay type of blow-out fracture was revealed. Bone fragments and prolapsed orbital soft tissues were elevated and a terramycin antral pack was used to support the orbital floor. There was no residual diplopia.

Roentgen Findings: December 24, 1960. The erect Waters' view showed a depression of the fractured floor of the right orbit into the upper

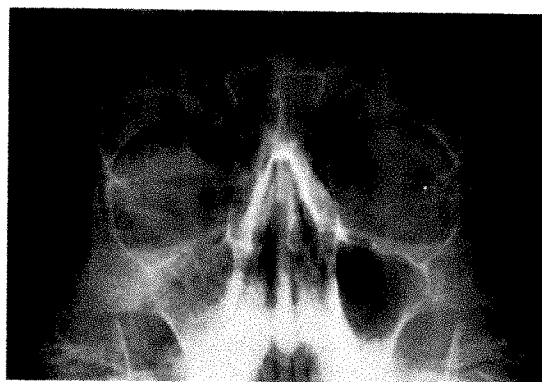


FIG. 9. Case vii. Waters' view shows a depression of the fractured floor of the right orbit into the upper third of the right antrum and orbital soft tissue.

third of the right antrum together with orbital soft tissue. The right antrum was opacified by hemorrhage. There was emphysema of the right orbit. A fracture of the medial orbital wall with opacification of ethmoid cells was also noted.

CASE VIII. Fig. 10, *A* and *B*. P.V., a 51 year old white female, was in an automobile accident and injured her left eye 4 months previously. Her complaints were all referable to an imbalance of ocular motility. Since there was a negligible amount of enophthalmos, treatment consisted of surgery of the extra-ocular muscles and no attempt was made to correct the orbital fracture.

Roentgen Findings: November 15, 1957. The Waters' view and the supine laminagram revealed a broad herniation of orbital soft tissues into the upper half of the left antrum through a blow-out fracture of the floor of the orbit. The prolapsed orbital fat appeared to be transparent.

CASE IX. Fig. 11, *A* and *B*. M.P., a 36 year

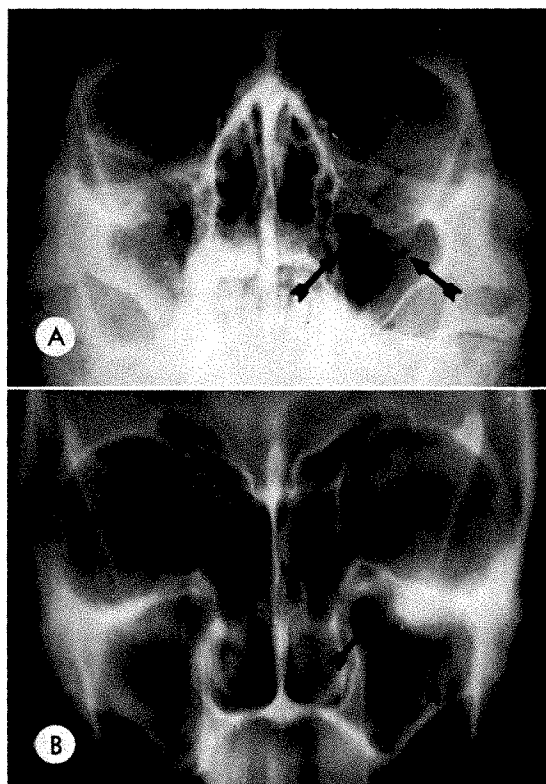


FIG. 10. Case VIII. (*A*) Waters' view and (*B*) laminagram show a broad herniation of orbital soft tissues into the upper half of the left antrum.

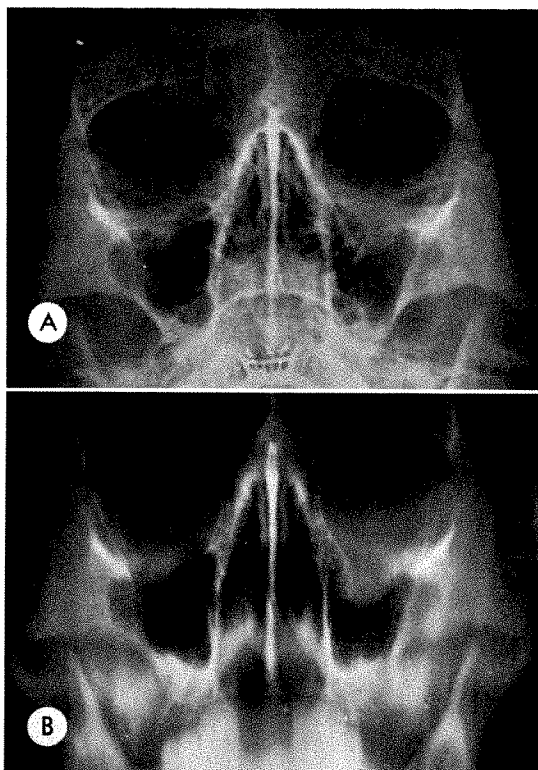


FIG. 11. Case IX. (*A*) Waters' view and (*B*) laminagram show transparent cyst-like, soft tissue density in the upper third of the left antrum.

old white female, was struck in the left orbit by a fist 1 week prior to admission. Her chief complaint was diplopia. The fracture site was approached transantrally and infra-orbitally. An iliac bone graft was used to repair the fracture after the incarcerated muscles were released. The fields of diplopia were decreased; some diplopia on extreme gaze persisted.

Roentgen Findings: August 7, 1959. The erect Waters' view and the supine laminagram revealed a transparent cyst-like, soft-tissue density in the upper third of the left antrum along with depressed bone fragments of the orbital floor. The laminagram confirmed the presence of a blow-out fracture of the orbital floor with greater clarity.

CASE X. Fig. 12. H.C., a 27 year old white male, was struck in the left eye with a fist, 3 days prior to initial examination. There was no diplopia. The chief complaint was referable to soft-tissue injury. The patient refused surgery and did not return to the clinic for follow-up.

Roentgen Findings: December 27, 1960. The

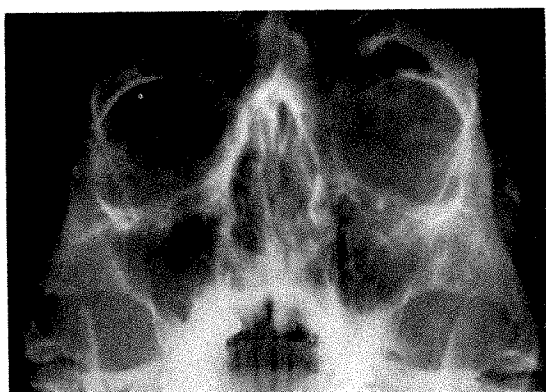


FIG. 12. Case x. Waters' view shows a fracture of the floor of the left orbit with a lobulated cyst-like, soft tissue mass projecting below the floor of the orbit.

erect Waters' view revealed a fracture of the floor of the left orbit with a lobulated cyst-like, soft-tissue mass projecting below the floor of the orbit into the upper half of the subjacent antrum.

CASE XI. Fig. 13. A.S., a 19 year old white male, was struck in the left eye 1 day prior to admission. The chief complaint was diplopia on extreme upward gaze. An infra-orbital approach was employed. The fracture of the orbital floor was bridged with a silicone implant 3.5 cm. $\times$ 3 cm. $\times$ 2 mm. Some diplopia persisted 3 months postoperatively.

Roentgen Findings: December 19, 1960. The erect Waters' view demonstrated a prolapse of orbital soft tissues into the upper medial third of the left antrum through a fractured orbital floor. The fragments were well seen.

CASE XII. Fig. 14, A and B. A.S., a 51 year

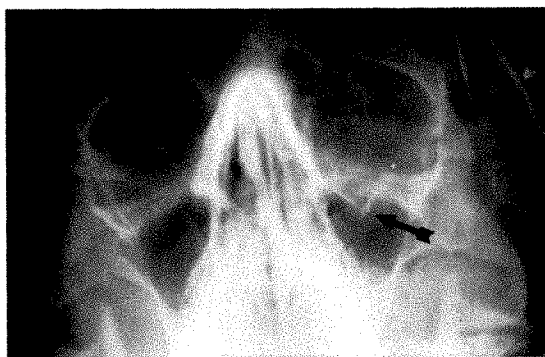


FIG. 13. Case XI. Waters' view shows a prolapse of orbital soft tissues into the upper medial third of the left antrum.

old white male who struck his left eye on the corner of a bed, was first seen 1 week after injury. His complaint was diplopia. A roentgen evaluation was made and the patient refused surgery. Three months later the diplopia was complicated by progressive enophthalmos.

Roentgen Findings: November 20, 1957. The erect Waters' view and the supine laminagram showed a herniation of orbital soft tissue and bone fragments into the upper half of the left antrum. The laminagram confirmed a blow-out fracture of the left orbital floor with depression of orbital soft tissues and bone fragments. A fracture of the medial orbital wall was also clearly delineated with a medial displacement of orbital soft tissues into the plane of the ethmoid cells.

CASE XIII. Fig. 15. H.S., a 44 year old white female, injured her right eye in an automobile accident 10 months previously. Her presenting complaint was a right enophthalmos of 8 mm. A combined infra-orbital and transantral approach was used. An iliac bone graft was applied to re-establish the defect in the orbital floor. The volume of orbital soft tissue was increased with insertion of fascia from the right

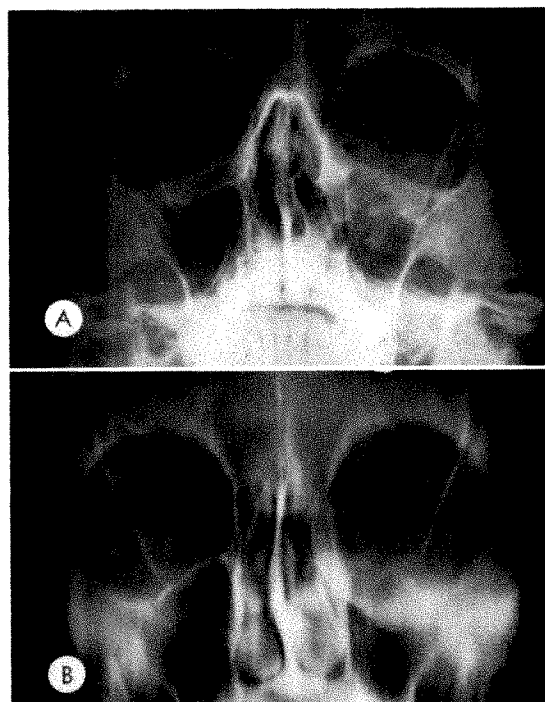


FIG. 14. Case XII. (A) Waters' view and (B) laminagram show herniation of orbital soft tissue and bone fragments into the upper half of the antrum.

thigh. Two weeks postoperatively the enophthalmos was correct to within 1 mm.

Roentgen Findings: March 7, 1961. On the erect Waters' view a very opaque right antrum was noted. The hemorrhage into the antrum obscured the fracture fragments and the herniated orbital soft tissues.

CASE XIV. Fig. 16, *A* and *B*. A.J., a 52 year old white male, was struck with a fist in the left eye 5 days prior to admission. His initial complaint was ecchymosis with proptosis of the left eye. There was no ocular rotation. Prior to the roentgen examination, the blood in the left antrum was aspirated and air substituted. A transantral approach was utilized to reduce the fracture and an aureomycin gauze packing was employed to maintain the integrity of the orbital floor.

Roentgen Findings: May 24, 1961. The Waters' view and the supine laminagram revealed a depressed fracture of the left orbital floor with downward herniation of orbital tissues profiled by a trace of air in an opaque left antrum. A fracture of the medial orbital wall was indicated by opacification of ethmoid cells. There was emphysema of the left orbit.

SUMMARY

Blow-out fracture of the orbital floor is caused by a sudden traumatic increase of intra-orbital pressure secondary to a blow from a round, hard object of a diameter larger than that of the orbital rim. This type of fracture is usually associated with prolapse of orbital bone fragments and soft tissues into the underlying maxillary sinus.

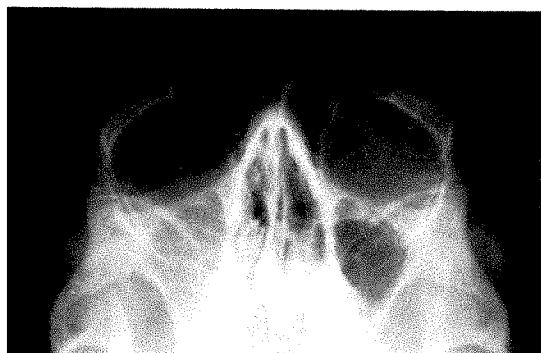


FIG. 15. Case XIII. Waters' view shows an opaque right antrum.

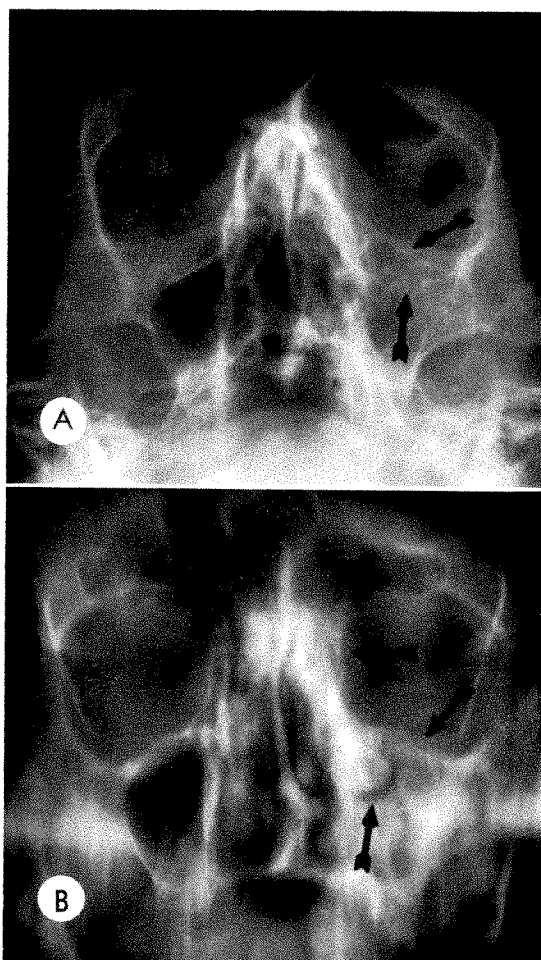


FIG. 16. Case XIV. (*A*) Waters' view and (*B*) laminagram show a depressed fracture of the left orbital floor with downward herniation of orbital tissues profiled by a trace of air in an opaque left antrum.

The clinical signs of blow-out fracture of the orbit are enophthalmos, downward displacement of the eyeball, impaired rotation of the eyeball, diplopia and sensory disturbances of the skin supplied by the infra-orbital nerve.

The clinical syndrome of blow-out fracture is not as widely publicized in the medical literature as it should be. The injury causes cosmetic deformity and functional impairment of vision as evidenced by enophthalmos and ptosis of the eyeball and diplopia.

Early treatment ensures the best cosmetic and functional results. Therefore, early diagnosis established by proper roent-

genographic techniques and interpretation is important. The Waters' view and the supine anteroposterior laminagram are discussed as essential diagnostic aids. The main roentgen signs are: (1) fragmentation of the bone of the orbital floor; (2) depression of bony fragments; and (3) prolapse of orbital soft tissues into the upper half of the subjacent maxillary sinus.

Effective surgical repair is possible by an infra-orbital or transantral approach. A combination of the two is sometimes necessary. Autogenous bone graft is often used for bridging the bone defect in the fractured orbital floor. With the transantral approach, packing or a balloon may be left in the underlying antrum to support the fractured floor for a period of 2 weeks.

The blow-out fracture of the orbit is discussed and 14 cases are presented.

The importance of roentgenologic diagnosis of this condition by comprehensive, thorough and individualized examination is described.

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MASTOIDITIS AND CHOLESTEATOMA: A ROENTGEN APPROACH*

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THE indications and purpose for middle ear and mastoid surgery have undergone change within the recent past. Compere⁶ has emphasized the reason for this revision, *i.e.*, reconstructive surgery for the improvement of hearing. Another factor is the change in the nature of acute and chronic infection of the middle ear and mastoid as a result of antibiotic therapy.

The advent of tympanoplasty has made it imperative to exclude chronic infection (cholesteatoma) prior to surgery. The presence of residual infection will alter the management of the individual case, *i.e.*, tympanoplasty with or without mastoidectomy. Often this decision is made clinically, but at times additional information as to the presence and the extent of disease can be obtained from roentgen examination. Antibiotic therapy has produced atypical cases of middle ear and mastoid disease. Myers¹⁶ has stated that 20 per cent of patients with chronic ear disease may develop otitic complications and, therefore, should have the benefit of surgery. Here, also, roentgen examination can give information helpful to the diagnosis of disease.

This resurgence of interest in middle ear and mastoid disease^{5,6,7,18} has stimulated us to obtain better roentgenographic evaluation of the temporal bone. With this purpose in mind, we have reviewed our middle ear and mastoid material to see what our accomplishments were and what could be done to improve our diagnostic ability. In addition, we wished to establish a regimen that gives good diagnostic results, but yet is sufficiently practical so that it can be done with conventional equipment and without undue technical difficulty.

The temporal bone is a difficult area to

examine and interpret. The radiologist's familiarity with the anatomic structures and their relationships, his ability to properly project these structures on roentgenograms, and his diagnostic acumen in interpreting the normal and abnormal are of prime importance.

ANATOMY AND DEVELOPMENT

The three portions of the temporal bone which are of specific interest in otologic radiology are the tympanic, mastoid and petrous. Figure 1A demonstrates a coronal section through these portions of the temporal bone. We place much emphasis in our diagnosis of disease on the attic and antral area. The attic contains the head of the malleus and incus and is situated immediately above the middle ear. The antrum is located lateral to the attic and superior to the external canal. A lateral projection of the area of interest is seen through a sagittal section of the middle ear as shown in Figure 1B. The antrum is again seen superior and posterior to the middle ear. The attic is superior to the middle ear.

The middle ear is actually a wafer-shaped structure that has an anteroposterior and a cephalocaudad diameter of 15 mm., but a mesiolateral diameter of only 4 mm.⁸

The mastoid antrum varies in size, but various investigators^{26,27,31} give the maximum size in the cephalocaudad diameter as 12 mm. The mesiolateral diameter is 6 mm. in the inferior portion and 10 mm. in the superior portion. The antrum is surrounded by the mastoid portion of the temporal bone with the superior border being the tegmen tympani. The horizontal semicircular canal, an important landmark,

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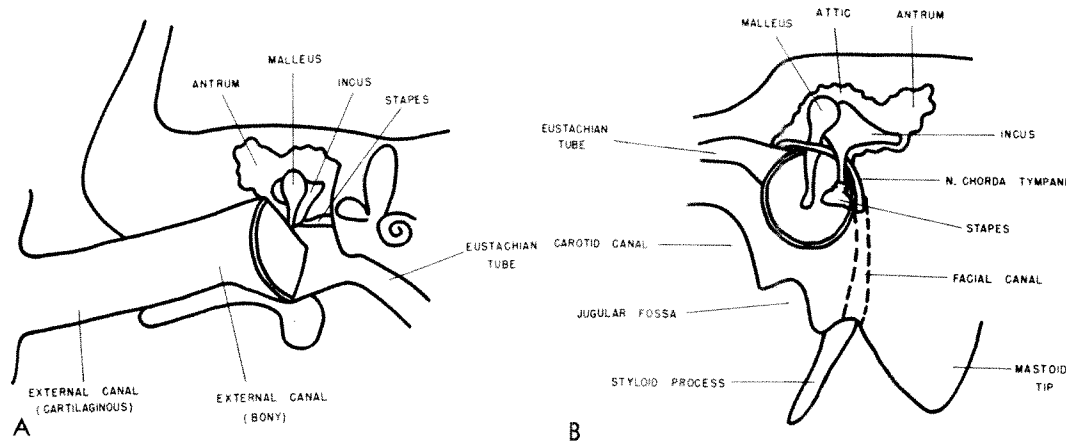


FIG. 1. The diagrams show the relation of the attic and antral area to the middle ear. The coronal section (A) is similar to a Stenvers view and the sagittal section (B) is similar to a Runström view. (Figure 1B is adapted from "Surgery of the Ear" by George E. Shambaugh, M.D., W. B. Saunders Company, Philadelphia, 1959.)

produces a bulge on the medial and posterior aspect of the antrum.²

The middle ear and eustachian tube form from the first pharyngeal pouch, which is entoderm, and they are lined with simple nonciliated cuboidal epithelium. The external ear forms from the first branchial groove, which is ectoderm, and it is lined with stratified squamous cell epithelium. Both of these structures grow towards each other and their point of junction is the tympanic membrane. The ossicles form from the first and second branchial arches and are covered with the epithelium of the middle ear.^{1,9}

The mastoid antrum forms as an out-pouching of the middle ear in the sixth fetal month. This degree of development is present in the infant at birth and up to the age of six months. The structures of the middle ear and inner ear are of their adult size at the time of birth. They are situated more laterally than in the adult and as growth and development occur, there is an apparent medial drift of these structures. However, this is only the differential growth of the petrous bone about the middle and inner structures.^{8,29}

Between the ages of six months and two years, there may be a gradual extension of air cells from the antral area to and including the mastoid tip. From the age of two to

adulthood, pneumatization can extend into the squama of the temporal bone and zygoma.²⁹

Roentgenographically, the mastoid has acquired adult appearance by the age of two and can be evaluated as an adult mastoid.²⁹

There are different degrees of normal development: (1) diploic and (2) pneumatized. The pneumatized mastoid is of (a) minimal, (b) moderate or (c) extensive development. Roentgenographically, the diploic mastoid and sclerotic mastoid (old disease) may be difficult to differentiate. Minimal cellular development shows only periantral air cells with the remainder of the mastoid diploic. Moderate and extensively pneumatized mastoids show air cell development in the mastoid and, at times, adjacent bones.

ROENTGENOGRAPHIC TECHNIQUE

The quality of the roentgen technique is a major factor for success in the evaluation of mastoids.⁷ Perfect technique must be aimed for continuously. The reviewed case material has shown that many of the errors in diagnosis were in studies which did not show the attic and antral area. Factors influencing mastoid technique are similar to those influencing all roentgenographic techniques. However, some aspects of tech-

nique are critical. A major cause of unsharp roentgenograms is patient motion. All the precautions concerning proper kilovoltage and focal spot are worthless with the first nod of the patient's head during an exposure. The patient should be comfortable (therefore, preferably in a sitting position) and some means of head immobilization utilized. We have found the Franklin head unit acceptable for this purpose (Fig. 2). The head clamps immobilize the patient well and the vertical tube swing permits cephalocaudal tube angulation. This apparatus has the disadvantage of having no horizontal tube angulation. Furthermore, it does not permit the patient's shoulder to be placed under the cassette holder, so that there is a degree of awkwardness in positioning. The Lysholm head unit overcomes the former disadvantage by allowing tube angulation instead of rotation of the patient. However, with careful positioning, any upright cassette holder can be utilized.

The equipment should permit a short subject-to-film distance for best detail.

We have found that a 1.0 mm. focal spot roentgen-ray tube will resolve the fine detail of the septal walls and is quite adequate. Although a 0.3 mm. focal spot is optimal, this is not felt to be necessary.

The kilovoltage should be sufficiently high (75–90 kvp.) to permit penetration of dense bone. Winderen and Zimmer²⁷ demonstrate the value of proper penetration with an example of the obscuration of a cholesteatoma with low kilovoltage. With the increase in kilovoltage, a grid (moving Potter-Bucky) is frequently necessary to preserve contrast (we use an 8:1 grid). Coarse stationary grids will detract from the quality of the roentgenogram. A small cone that will only encompass the examined area should be used to further decrease scatter and preserve contrast. We utilize a $1\frac{3}{4}$ inch diameter cone for the Runström and Stenvers and a $\frac{7}{8}$ inch diameter cone for the Mayer projections.

Average exposure for a Runström projection (Bucky) is 30 mas. (100 ma., $\frac{3}{10}$ sec.)

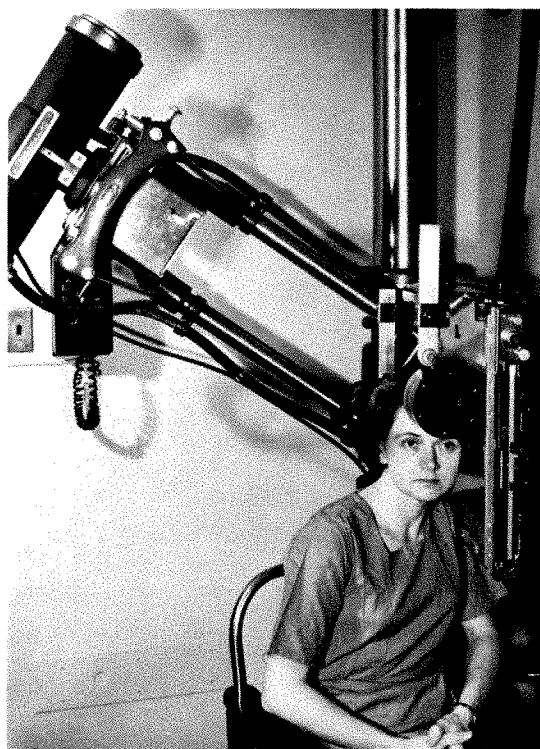


FIG. 2. Patient positioned for the Runström view with the Franklin head machine.

at 85 kvp. and for a Mayer projection (flash) 20 mas. (100 ma., $\frac{1}{5}$ sec.) at 80 kvp.

We employ only registered technicians in our department and do not have a technicians' school. However, no one technician does mastoid roentgenography exclusively. We feel that, if possible, one technician should be responsible for all mastoid roentgenography.

ROUTINE EXAMINATION

Through the years innumerable projections have been described for demonstrating the mastoid, but these views all fall essentially into two gross categories—lateral^{12,14,17,22,25} and anteroposterior projections of the mastoid. Many of the views are slight variations of one another and yield similar information, but at times the change in positioning to better demonstrate the attic and antral area is critical, *i.e.*, the change from the Law projection to the Runström projection.

After evaluation of various projections,

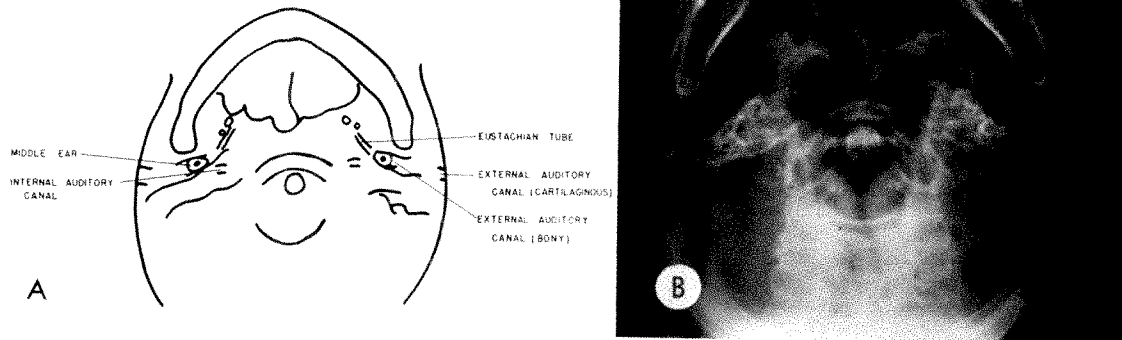


FIG. 3. Base projection. The diagram (A) illustrates the mastoid and middle ear seen on the roentgenogram (B). The middle ear is "triangulated" by the external and internal auditory canals and the eustachian tube.

we have chosen five views for a standard examination: Runström, Mayer, base, Stenvers and Chamberlain-Towne. The Runström and Mayer projections are critical in evaluation of the attic and antral area. The remainder of the views offer correlative information and rarely are the sole diagnostic projections.

The base view (Fig. 3, A and B) is excellent for initial evaluation of the mastoid. This single film with one roentgenographic exposure and one processing avoids the error of variation of technique. This view shows both mastoids and middle ears at the same time. The side in question can be

compared to the contralateral side for aeration (mastoid and middle ear). The presence or absence of ossicles in the middle ear can often be determined.

The critical and most valuable view in our hands is the Runström projection (Fig. 4, A and B). This projection has consistently been technically satisfactory. In addition it shows the cellular construction of the mastoid, *i.e.*, cell size and distribution, air content, cell wall integrity and thickness of septa. However, its major contribution is a good demonstration of the attic and antrum. Although other projections have been shown to better demon-

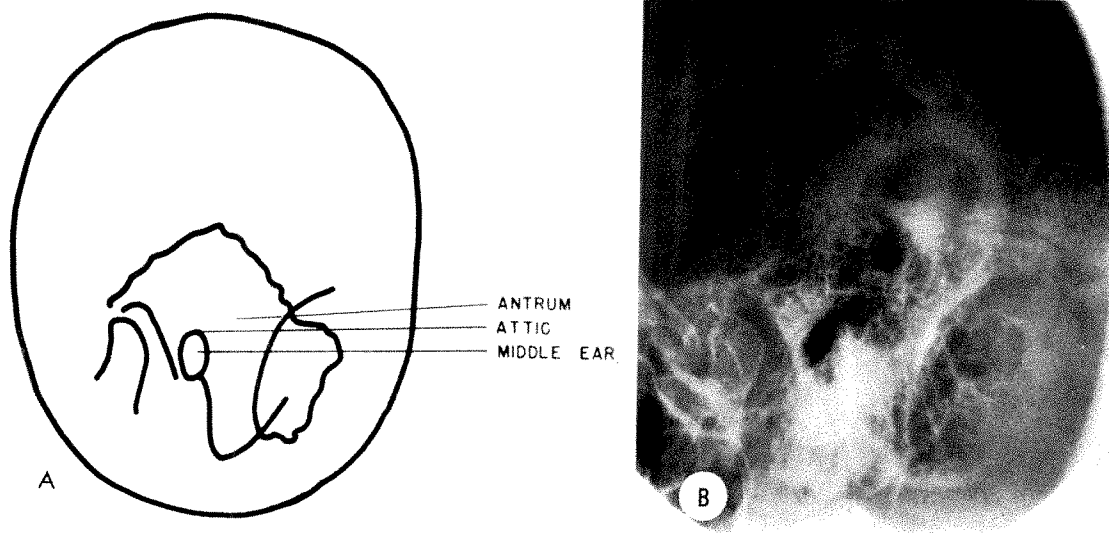


FIG. 4. Runström projection. The diagram (A) illustrates the attic and antral area seen on the roentgenogram (B). This view is also excellent for evaluation of cellular detail.

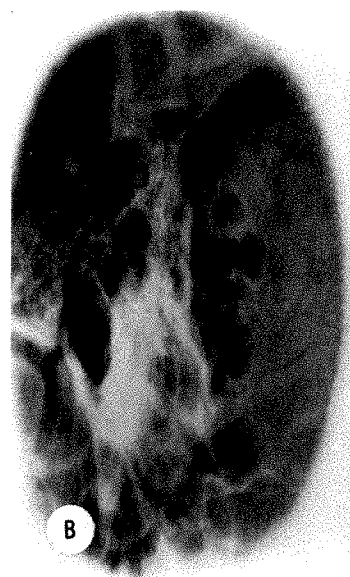
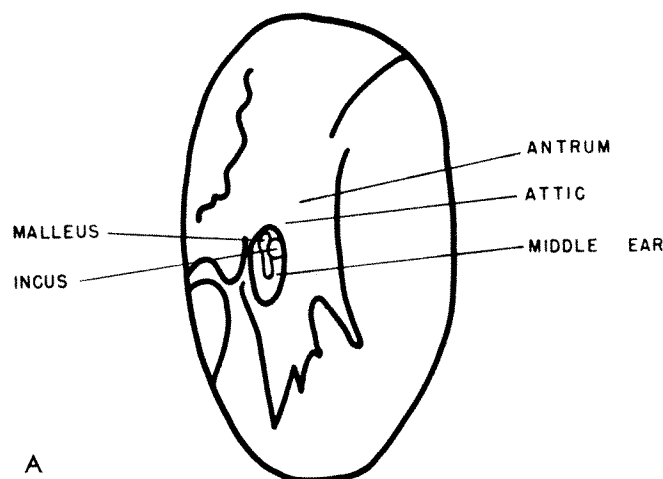


FIG. 5. Mayer projection. The diagram (*A*) illustrates the attic and antral area seen on the roentgenogram (*B*). This is a better demonstration of this area than in the Runström view. Due to variation of petrous pyramid angulation, the positioning is not exact. This is a cause of poor reproducibility of this view.

strate this area, the ease with which the projection is obtained and the consistency of diagnostic worth of the projection make this view the most valuable in our hands. Stereoscopy is an invaluable adjunct to the Runström projection. For instance, at times a vague attic or antral lucency becomes definite with depth perception, or a vague lucency may be definitely identified as part of the external ear by stereoscopy.

The Mayer projection (Fig. 5, *A* and *B*) gives an excellent demonstration of the attic and antral area, but, because of the

distortion produced by this projection, evaluation of cellular structure is only fair. In our hands this projection has not always been dependable for diagnosis because of the lack of reproducibility. Although we have not employed stereoscopy with this view, we feel it would be of aid in better evaluation of attic-antral disease.

The Stenvers projection (Fig. 6, *A* and *B*) again demonstrates the cellular construction of the mastoid, and also shows the entire petrous pyramid. A cholesteatoma must be quite large before it is identi-

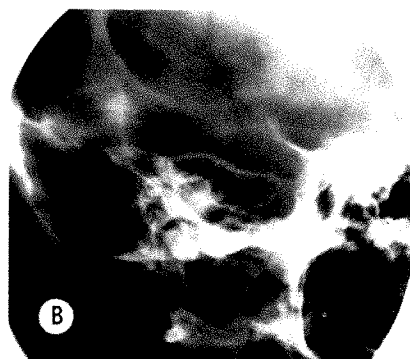
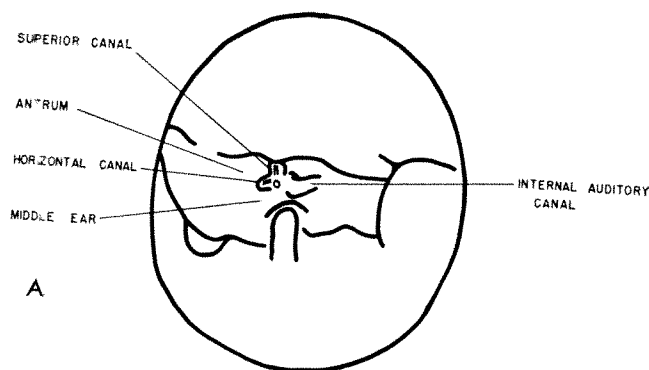


FIG. 6. Stenvers projection. The diagram (*A*) illustrates the relation of the mastoid antrum to the horizontal semicircular canal seen on the roentgenogram (*B*). This view also gives an evaluation of the degree of pneumatization.

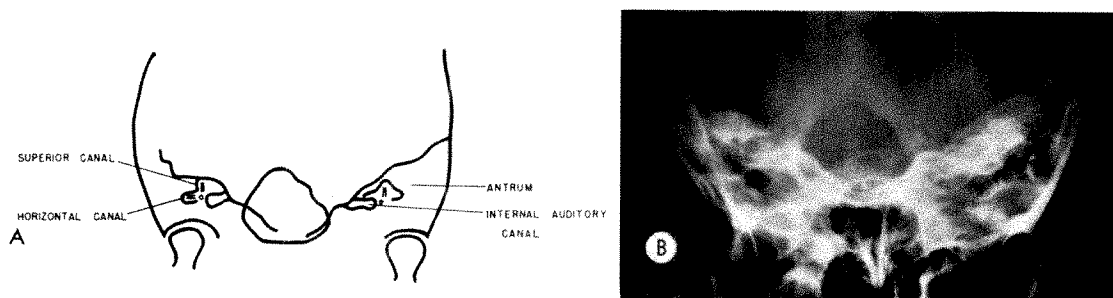


FIG. 7. Chamberlain-Towne projection. The diagram (A) illustrates the area of the mastoid antrum seen on the roentgenogram (B). It is possible to visualize a normal antrum in a sclerotic mastoid.

fied as a lucency lateral to the horizontal semicircular canal. We have not identified the normal antrum in a dense, sclerotic mastoid in the Stenvers projection.

The Chamberlain-Towne projection (Fig. 7, A and B) is essentially an anteroposterior projection and a similar evaluation of the mastoid can be made as in the Stenvers view. However, here we are able to identify the normal antrum in a dense, sclerotic mastoid. We can correlate findings revealed by the lateral projections (Runström and Mayer) with an enlarged antrum in the Chamberlain-Towne projection and make the interpretation of cholesteatoma more definitive.

Additional projections and methods have been suggested for mastoid examination. We have not utilized them in the routine examination.^{3,21} One of these, the Chaussé III view, has received a considerable amount of attention. In the hands of its proponents, good demonstration of the attic and antral area has been shown. However, as in the Mayer projection, positioning is very critical and it is felt that an apparatus such as the Lysholm head unit would be necessary.

A recent addition to accurate positioning for mastoid study is the image intensifier.³⁰ The desired view is readily produced, as with all fluoroscopic positioning. However, we have not utilized this technique in our routine work to date.

An adjunct to conventional diagnostic procedures is laminagraphy. This has been advocated for cases in which the diagnosis

of cholesteatoma is made clinically but not confirmed by conventional roentgen studies or the diagnosis is equivocal from the roentgenographic standpoint. Standard laminagraphy and the newly developed polytome are capable of increasing the diagnostic ability of the radiologist.^{11,20,26,28,31} We have not routinely examined mastoids with this technique.

PATHOLOGY

Various authors^{19,23,24,29} have given classifications of roentgenographic findings associated with a diseased mastoid. We use a modification of these descriptions and are able to ascribe our observations to one or more categories. The interpretations correlate well with the clinical and surgical findings.

(1) *Normal*. This consists of all degrees of pneumatization and diploic structure. The aerated cells are black, show thin bony septa and the septa are intact. The diploic mastoid has no cellular development, and, as noted before, may give difficulty in differentiation from the sclerotic mastoid.

(2) *Exudative Mastoiditis* (Fig. 8, A, B and C). This interpretation depends upon an aerated mastoid that has become "cloudy" as the result of exudation replacing the air in the cells. The cell septa are intact. This correlates well with the acute infectious process.

(3) *Mastoiditis with Bony Breakdown* (Fig. 9, A and B). This picture is similar to (2), but some septa are incomplete. This, we feel, indicates an osteolytic proc-

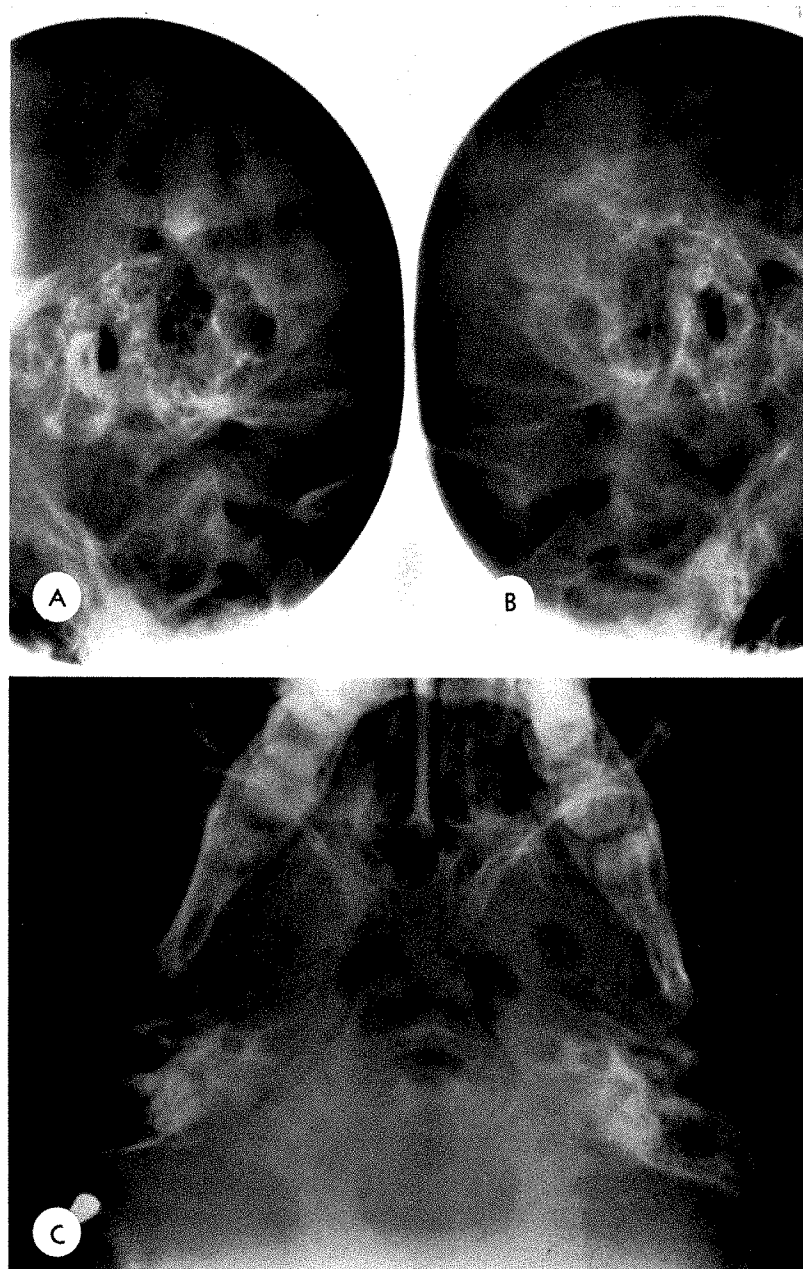


FIG. 8. Exudative mastoiditis. The "black" of the normal mastoid (*A*) has been replaced by a haze on the affected side (*B*). This is also demonstrated on the base view (*C*) with associated clouding of the left middle ear. The remainder of the mastoid morphology (cell integrity, septal thickness, etc.) is normal.

ess. Clinical correlation has shown in the cases we have examined that actual bone necrosis occurred.

(4) *Chronic Mastoiditis* (Fig. 10, *A* and *B*). The appearance of thick septa had at one time been considered by us as a variation of normal. However, as clinical correla-

tion with disease has accumulated, we feel this represents chronic disease just as mucosal thickening in the paranasal sinuses represents disease.

(5) *Sclerotic Mastoid* (Fig. 11). The appearance of a dense, sclerotic mastoid represents old disease. Here the vital ques-

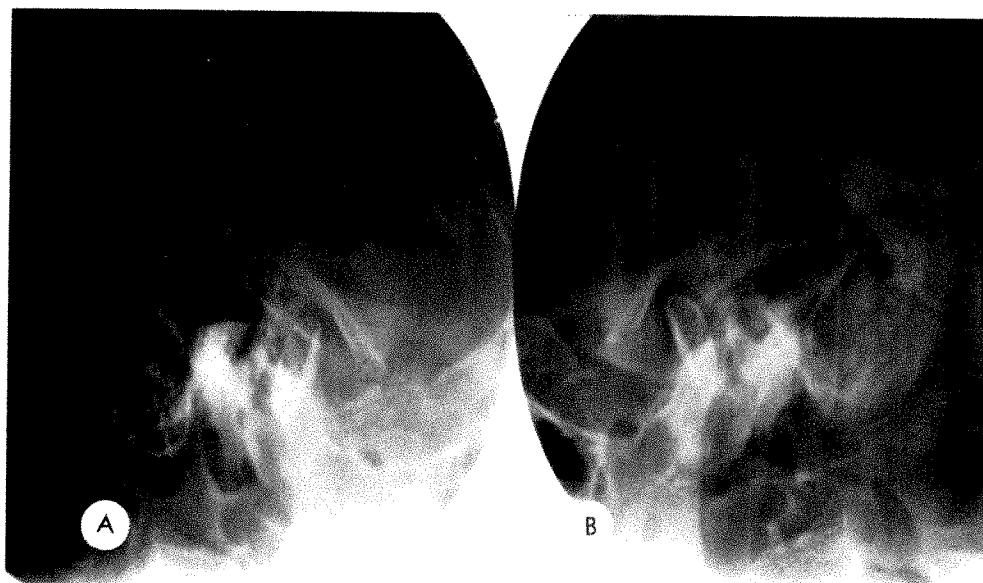


FIG. 9. Mastoiditis with bony breakdown. The left mastoid (A) is normal. The right mastoid (B) shows loss of integrity of cell walls in addition to over-all cloudiness.

tion is whether localized bony destruction representing cholesteatoma formation exists.

(6) a. *Attic Cholesteatoma* (Fig. 12, A and B). This is bony erosion localized in the attic. Cholesteatomas must be large before there is roentgen visualization.²⁶

b. *Antral Cholesteatoma* (Fig. 13, A, B, C and D). This is the extension of the

cholesteatoma into the mastoid antrum and then causing its enlargement.

c. *Extensive Cholesteatoma Formation*. This is the extension of the cholesteatoma farther out into the mastoid.

The term "cholesteatoma" remains controversial. The relation of the lesion of the middle ear to the cholesteatoma or epidermoid in other bones is not clear. The speci-

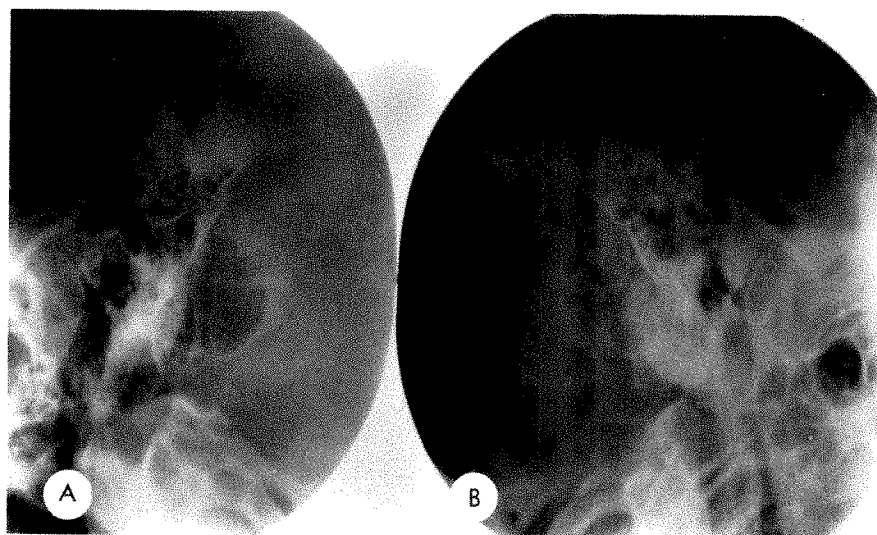


FIG. 10. Chronic mastoiditis. The right side (A) is normal. The left side (B) shows thickened septa of the mastoid cells which are air-containing.

mens taken from both roentgenographically and clinically diagnosed cholesteatoma have been reported by our pathology department as (1) cholesteatoma, (2) the "so-called cholesteatoma of the middle ear," (3) pseudo-cholesteatoma (to differentiate from the "true cholesteatoma"), (4) chronic inflammatory tissue with cholesterolosis, and (5) chronic inflammatory tissue. We are designating a localized erosive or destructive lesion in a sclerotic mastoid with one of the above five pathologic interpretations a cholesteatoma.

RESULTS

We have reviewed the operative findings of 103 ears in 100 patients on whom pre-operative roentgenograms had been obtained. The results shown are separated into two groups: (a) the interpretation on the initial report, and (b) the interpretation on review of the roentgenograms by one of us (H.J.W.). In a first comparison, the material consists of 103 diseased ears including acute and chronic disease (Table I). The second comparison consists of 85



FIG. 11. Sclerotic mastoid. The mastoid area is dense and airless. No evidence of bony erosion is seen.

cholesteatomas of the 103 ears (Table II). The interpretation has been called correct



FIG. 12. Attic cholesteatoma. The Runström projection (*A*) shows erosion of the attic area. This is better demonstrated in the Mayer projection (*B*).

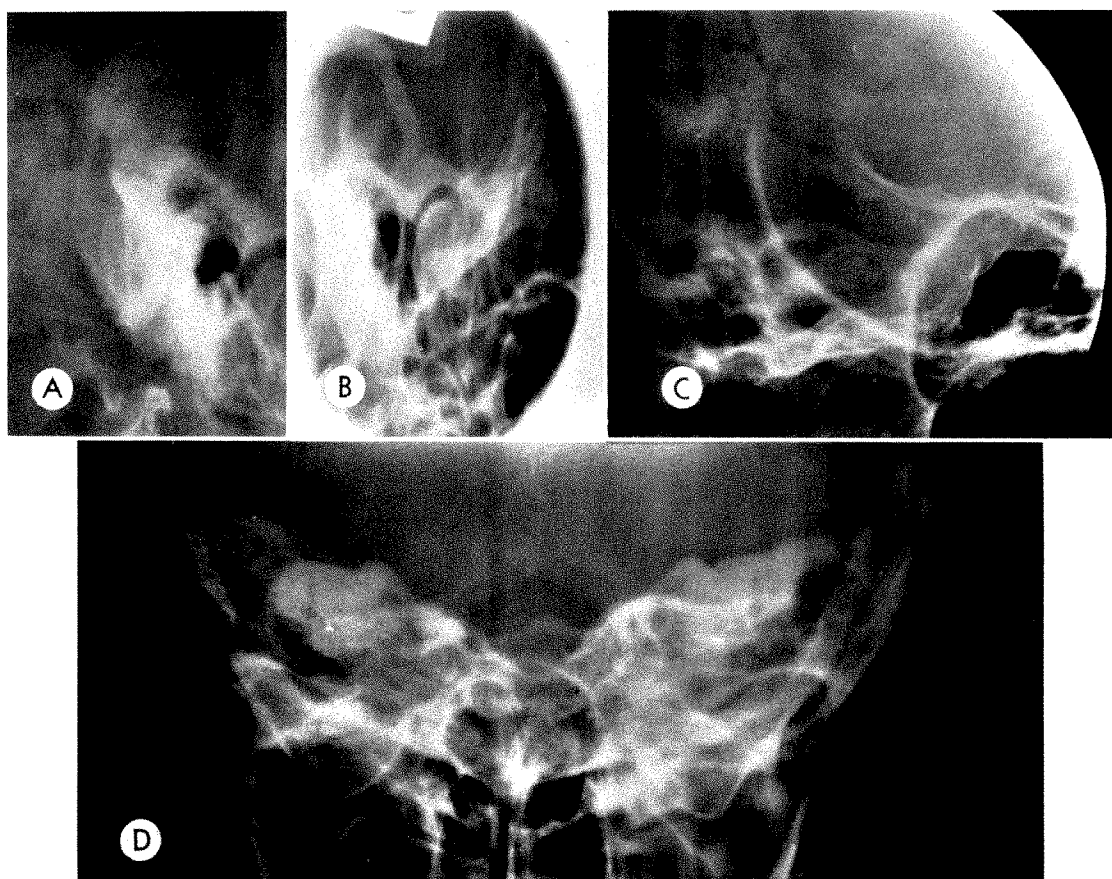


FIG. 13. Antral cholesteatomas. The Runström (*A*) and Mayer (*B*) projections show an area of lucency extending from the middle ear out into the antral area. The Stenvers (*C*) and Chamberlain-Towne (*D*) views demonstrate an area of lucency lateral to the horizontal semicircular canal, also representing a cholesteatoma.

only if the roentgenographic findings correlated with the operative findings. The over-diagnosis of disease, *i.e.*, calling an attic cholesteatoma an antral cholestea-

toma, and the under-diagnosis of disease, *i.e.*, calling an antral cholesteatoma a sclerotic mastoid, are considered incorrect diagnoses.

The roentgen diagnosis of cholesteatoma (Table II) in our material compares favorably with other reports in the literature. In 1936, MacMillan¹³ reported 584 cases with a diagnostic percentage of 50 per cent. Holmes¹⁰ and Chiat and Kittredge⁴ have had similar findings. Winderen and Zimmer,²⁷ in a very complete analysis of middle ear disease, had a 57.9 per cent correlative diagnostic percentage. Recently, Jensen *et al.*,¹¹ in a review of 80 cases and the efficacy of various projections in diagnosis, had a diagnostic percentage of 70 per cent without laminagraphy.

TABLE I

COMPARISON OF ROENTGEN FINDINGS WITH OPERATIVE FINDINGS IN 103 CASES OF DISEASED EARS INCLUDING ALL ASPECTS OF INFLAMMATORY DISEASE

	Group a Original Reading (per cent)	Group b Reviewed Reading (per cent)
Correctly diagnosed	65	73
Over-diagnosed	9	8
Under-diagnosed	26	19

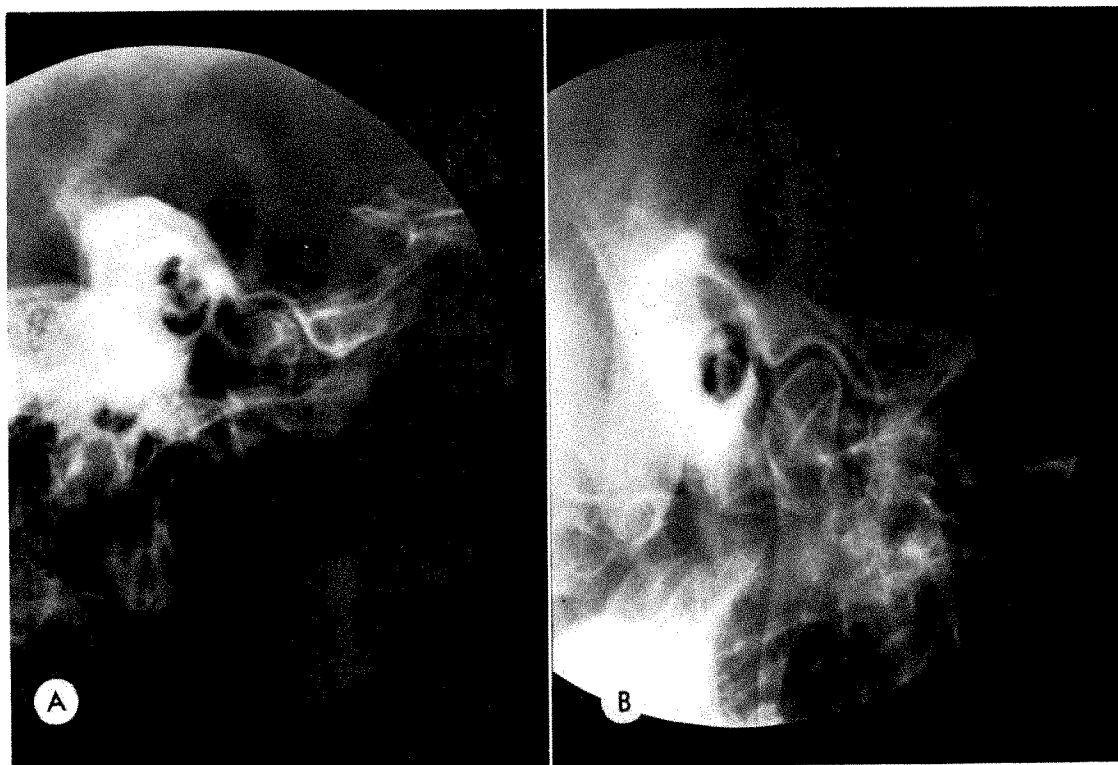


FIG. 14. The Law projection (*A*) shows a sclerotic mastoid with equivocal, if any, demonstration of an antral cholesteatoma. The Runström projection (*B*) well demonstrates the cholesteatoma.

Our cholesteatoma diagnostic percentage used to average 50 per cent¹⁵ as in many other case series. The percentage increased to 58 per cent with the addition of the Runström projection. There was a further increase of our diagnostic percentage to 70 per cent with a review of the cases. The major area of misdiagnosis in our material was in the under-diagnosis of disease. This is evident in both the original and reviewed readings. The pathologic process

most frequently misinterpreted was the attic cholesteatoma.

A portion of the higher diagnostic percentage that we achieved today is the result of the Runström projection. When this projection was added to the previous routine study, the lateral view had been the Law projection. Many times a cholesteatoma is evident on the Runström projection when it was not seen or was equivocal on the Law projection (Fig. 14, *A* and *B*; and 15, *A* and *B*). A second factor producing a greater diagnostic percentage was the better interpretation of the roentgen study. The results (Tables I and II) show a marked reduction in under-diagnosis in the revised interpretation with little change in the incidence of over-diagnosis. The more accurate diagnostic percentage in the reviewed reading is a manifestation of an experienced radiologist with a specific interest in mastoid roentgenography.

TABLE II

COMPARISON OF ROENTGEN FINDINGS WITH OPERATIVE FINDINGS IN 85 CASES OF CHOLESTEATOMAS

	Group a Original Reading (per cent)	Group b Reviewed Reading (per cent)
Correctly diagnosed	58	70
Over-diagnosed	6	5
Under-diagnosed	36	25

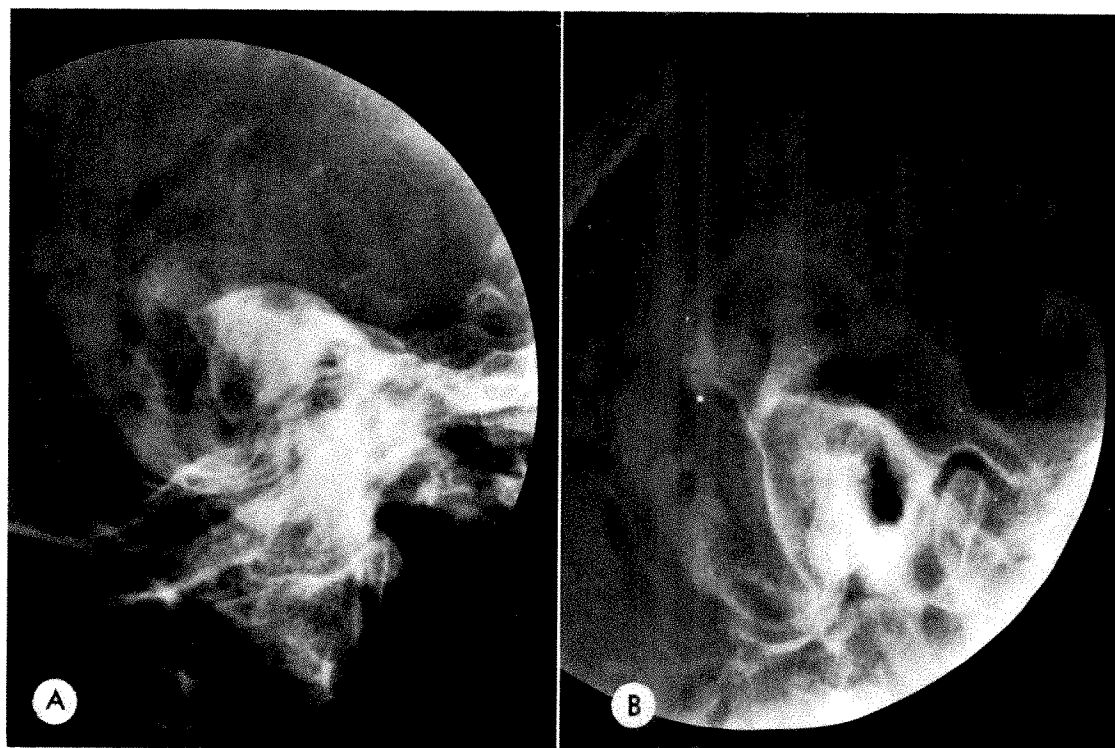


FIG. 15. Here, as in Figure 14, the Law projection (*A*) is inadequate in demonstrating the antral cholesteatoma that is well seen in the Runström projection (*B*).

CONCLUSIONS

Temporal bone roentgenography is helpful to the otologist in evaluating middle ear and mastoid disease.⁵ The follow-up of mastoid studies with surgical findings adds to the experience of the radiologist and permits him to make better interpretations of the roentgen study. Clinical history is of course of invaluable aid. Thus, although the importance of technique is not to be minimized, a factor of value is the experience and interest of the radiologist, and the clinical aid given to him by the otologist.

Employing a "realistic" examination of the temporal bone, we have been able to correlate 73 per cent of our interpretations with the surgical findings. The increase in diagnostic percentage is due partially to the addition of the Runström projection to our examination. A recurrent problem in radiology is that of the elaborateness of the examination. There is no doubt in our

minds that additional techniques would yield some additional information. However, we feel that a point of diminishing return would soon be reached. It is estimated that 20 per cent of all cholesteatomas are in the attic,²⁶ and it is well known that attic cholesteatomas must be large before they produce bony changes that can be identified roentgenographically. This was a major area of diagnostic error in our material. Thus, although polylaminagraphy and special projections give a greater diagnostic percentage, the maximum ability in diagnosing cholesteatomas, especially early attic lesions, approaches a limit. The increase in diagnostic ability may not be proportional to the complexity and additional cost of these techniques. By employing a "realistic" examination, such as described, it is not difficult for all interested in temporal bone roentgenography to obtain good roentgenograms. An acceptable diagnostic yield is dependent upon the

radiologist's insistence on meticulous roentgenographic technique and his interest in temporal bone pathology.

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We wish to express our appreciation to W. Robyn Hardy, M.D., whose stimulation led us to routine use of the Runström projection. We are also grateful to David Myers, M.D., for his critical review of this article, and to the members of the Otology Department, Temple University Medical Center, for their kind cooperation in supplying us with case material and surgical findings.

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HYPEROSTOSIS CRANII IN A NORMAL POPULATION*

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HYPEROSTOSIS cranii, nodular or smooth thickening of the inner table of the skull, is a fairly common finding in skull roentgenography, though pronounced changes are more rare. Most of the cases, 94-99 per cent, in the series of different authors have been women.

REVIEW OF THE LITERATURE

Stewart,²⁸ who was the first to consider the clinical and pathoanatomic observations parallelly, regarded the condition as a syndrome in which hyperostosis, obesity and virilism are of hypophysial origin. The same view was expressed by Moore,¹⁹ who also introduced the following roentgenologic classification of the hyperostotic changes: (1) hyperostosis frontalis interna (HFI), in which the nodular thickening is limited to the area of the frontal bone; (2) nebula frontalis (NF), in which smooth thickening of the frontal bone is present; (3) hyperostosis calvariae diffusa (HCD), in which all the flat bones of the cranium are thickened; and (4) hyperostosis frontoparietalis (HFP), in which the thickening is localized to the region of the frontal and parietal bones. Moore also found that hyperostosis of the cranial bones may occur without clinical symptoms. No other bony changes are observed with the syndrome.¹⁸

Neuropsychiatric symptoms, psychic anomaly or mental retardation, and headache have not infrequently been recorded in association with cranial hyperostosis.^{3,19,20,21,26} Several workers have reported a correlation between diabetes mellitus in advanced age and cranial hyperostosis.^{1,22,23}

Hyperostotic changes in the skull have been noted by Di Chiro and Caughey⁵ in a great percentage of patients with myotonic dystrophy, the changes occurring with

equal frequency in both sexes. The same authors observed that the cranial changes in these cases were most pronounced in patients who had developed hypogonadism.

Several investigators, on the other hand, have questioned the existence of any clinicopathologic significance of cranial hyperostosis.^{7,10,15,23,27} Henschen¹⁵ was of the opinion that hyperostosis frontalis interna is a fairly common finding associated with senility in women. A familial occurrence of hyperostosis has also been recorded.^{6,12,14} Some reports published in the last few decades have mentioned cranial hyperostosis in young subjects,^{3,12,17} whereas earlier series generally were comprised solely of middle-aged and old persons.

ETIOLOGY

The etiology of hyperostotic cranial changes is unknown. Several researchers have suggested endocrinopathologic factors as the cause but both the histologic studies and the hormone determinations made to date have resulted in findings which are partly contradictory. Calamé² observed masculinization in women and feminization in men in his series, and he attributed this to a change in the function of the adrenal gland. Some changes have been reported in the secretion of sex hormones.³⁰ No difference from normal series has been noted, however, in the secretion of 17-ketosteroids.^{12,23,27} The role of the hypophysis has interested many workers. Morel²¹ observed proliferation of acidophilic cells; Henschen¹⁶ reported proliferation of both acidophilic and basophilic cells. No changes were noted by Floderus¹⁰ in the anterior lobe of the hypophysis. Based on autopsy material, Heino¹³ established the fact that adenomas of the anterior

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hypophyseal lobe were more numerous in cases of hyperostosis cranii than in controls. The mean weight of the adrenal gland was also somewhat greater in hyperostotic patients. Concomitant symptoms of hyperestrogenemia and hyperostosis have been observed,^{24,29} and, as mentioned above, in myotonic dystrophy hyperostotic changes have been found to be most pronounced in connection with hypogonadism.⁵

INCIDENCE

The incidence of hyperostosis cranii in a normal population has been little studied. Gershon-Cohen *et al.*¹¹ roentgenologically established the presence of cranial hyperostosis in 62 per cent of the healthy inmates of a home for the aged. The changes were present only in women. A high incidence, 14 per cent, was noted among young women seeking admission to a nurses' training school.⁴

THE PRESENT STUDY

The purpose of the present study was to determine the extent to which roentgenologic changes of cranial hyperostosis occur in a normal population and to shed additional light on the question of whether hyperostosis cranialis interna is a disease of clinical and pathologic significance or an insignificant secondary finding.

MATERIAL AND METHOD

Skull roentgenograms were taken in a series of 982 healthy subjects. A note was made of previous illnesses and symptoms which might be associated with cranial hyperostosis (headache, obesity, goiter, disorders of menstruation, cranial traumas). The series was composed principally of three population groups: (1) Group I, girls and boys from 15–20 years of age; (2) Group II, women at the age of sexual maturity, most of them pregnant; and (3) Group III postfertile women and old persons of both sexes. The distribution was as follows:

Groups	Females	Males
I (at the age of puberty)	146	186
II (at the age of fertility)	249	
III (postfertile)	253	29
Total	648	215

In addition, the control material consisted of 119 skull roentgenograms of men who had been treated for various traumas at the Surgical Department of the Central Hospital, University of Helsinki (Group IV). The age of these patients ranged from 22 to 82 years (mean age was 42.5). Complete data on the past history were not available for this group.

Skull roentgenograms, according to Henschel,¹⁶ are sufficient to establish the diagnosis of cranial hyperostosis, and Moore²⁰ considered that the lateral view of the skull was enough for the purpose. In the present work an anteroposterior roentgenogram was taken to supplement the lateral view, but it was not decisive for the interpretation in some of the cases.

The pregnant women and the majority of those at the age of fertility (Group II) were roentgenographed routinely on 24×30 cm. film (focus film distance 65 cm.) (Fig. 1). The roentgenograms of the aged (Group III) were taken at mass examinations in a home for the aged and in the geriatric out-patient department, and the

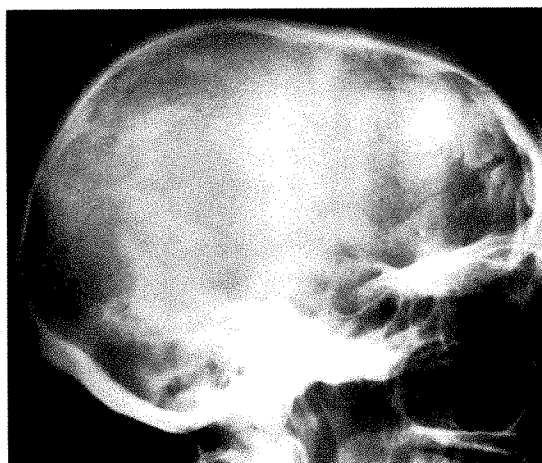


FIG. 1. Conventional roentgenogram showing Grade II hyperostosis frontalis interna (HFI).

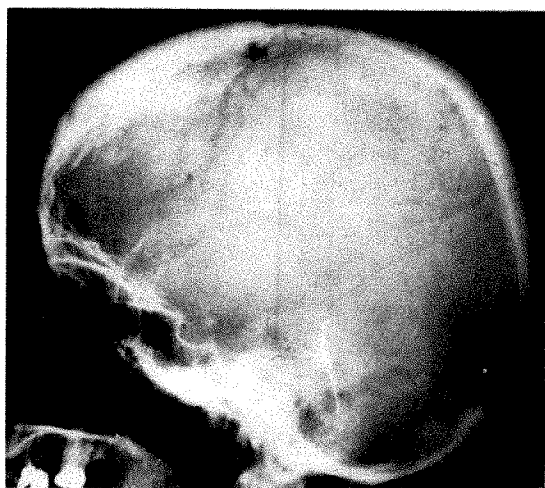


FIG. 2. A fluorophotograph showing Grade II HFI. (Film size, 7×7 cm.)

subjects at the age of puberty (Group I) were examined in trades training schools. These roentgenograms were fluorophotographs on 7×7 cm. film (focus screen distance 81 cm.) (Fig. 2). The fluorophotographs were examined with a magnifying glass and, when necessary, by projecting them at the size of a conventional skull roentgenogram.

For interpretation of the roentgenograms, the authors followed the classification introduced by Moore.¹⁹ The criterion for HCD was a minimum thickness of 1 cm. measured on the 24×30 cm. roentgenogram in the region of the flat bones of the entire, or almost the entire, skull. A corresponding thickness in the region of the frontal bone and the parietal bone was the criterion for HFP. Each of the authors examined the roentgenograms independently, and roentgenograms which were open to interpretation were re-examined by them jointly.

RESULTS

Hyperostotic changes were established in 117 of the 982 roentgenographed skulls of the present series, *i.e.*, in 12.2 per cent. Changes were present in 108 of the 648 women (16.7 per cent) and in 9 of the 334 men (2.7 per cent). Tables I and II show the incidence of hyperostosis cranialis in-

terna and the associated clinical findings in the different groups. Hyperostosis was most frequent in the women of postfertile age (22 per cent) and in women of fertile age (17 per cent). The incidence of hyperostotic changes was distinctly lower, only 7 per cent, in female subjects at the age of puberty. Changes were established in less than 3 per cent in all the male groups.

Comparison of the incidence of hyperostosis in the different groups of females revealed a statistically significant difference between the young girls and both of the older age groups ($P=0.01$). The difference between the fertile and postfertile groups was not statistically significant. The age distribution of the positive female cases was also compared with the theoretically expectable age distribution, *i.e.*, the distribution of the 108 positive cases by age classification in ratio to the age distribution of the total material. The χ^2 -test was applied for the comparison. It revealed a highly significant difference ($P=0.001$) between the age distributions. Figure 3 shows the distribution of the positive cases by age groups. The incidence rose to the 50-60 age group, where it reached its maximum, 35 per cent. Then it fell to about half in the older age groups.

A fairly large number of hyperostotic women in Groups II and III complained of headache (Table I). Headache occurred in 21 per cent of the former and in 58 per

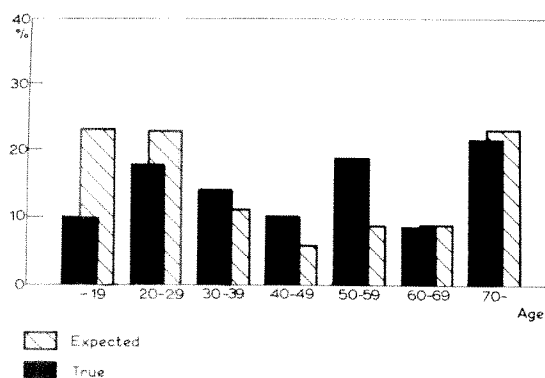


FIG. 3. Graph showing the distribution, according to age, of the female cases of hyperostosis cranialis (black columns) compared with the theoretically expectable age (shaded columns).

TABLE I

CLINICAL FINDINGS IN FEMALES WITH HYPEROSTOSIS CRANII AS COMPARED TO NORMAL

Group	No. of Cases	Per Cent	Obesity		Goiter		Headache		Skull Trauma	
			No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Group I (Puberty)	146									
Hyperostosis cranii	10	7	0	0	0	0	0	0	0	0
Normal	136	93	0	0	3	2.2	0	0	1	0.7
Group II (Fertile)	249									
Hyperostosis cranii	43	17	2	5	14	32	9	21	4	9
Normal	206	83	6	3	42	20	12	6	11	5
Group III (Postfertile)	253									
Hyperostosis cranii	55	22	11	20	10	18	32	58	5	9
Normal	198	78	10	5	22	11	55	28	30	15

cent of the latter, whereas the figures were considerably smaller, 6 and 28 per cent, respectively, for the normal women in those groups. The table shows further that obesity was more common in hyperostotic females in Group III than in the normal females in that group. The difference, however, was not statistically significant. No such difference was established in Group II, the incidence of obesity being fairly small both in the positive and in the negative cases. No differences were found in the incidence of goiter and cranial trauma.

There was no statistically significant difference in the mean age of menarche and menopause and the number of previous pregnancies between hyperostotic females and those with normal skulls (Table III).

The incidence of the different types of hyperostosis is shown in Tables IV and V. In the females, HFI and HCD were the most common forms; HFI was most frequent in Group III and HCD in Group II. No statistically significant differences were established in the distribution.

Neither obesity nor headache occurred in the positive cases of the male groups (Table II). The 1 case of hyperostosis diagnosed in Group III was over 70 years of age.

The only pronounced changes were in Group IV, the traumatic control material. A patient 46 years of age had Grade II HCD; the other HCD case was 52 and the only HFI case was 23 years old.

HISTOLOGY OF THE HYPEROSTOTIC CHANGES

As a control for the roentgenologic diagnosis, roentgenography was done on cranial specimens of 3 female cases brought to autopsy, at which time cranial hyperostosis had been established as a secondary finding with no distinct connection with the cause of death. Specimens were taken from the hyperostotic region of the skulls and, for examination of bone structure, contact roentgenography was performed on ground sections about 500 μ thick. Microscopic samples were prepared from decalcified bone. (These 3 cases are not included in the series presented above.)

The changes observed in the macroscopic roentgenograms (Fig. 4) agreed well with the pathoanatomic changes seen on inspection of the gross specimen. In microroentgenograms of the bony sections in 2 cases, the nodular inner table in the hyperostotic region was found to be thin;

TABLE II
CLINICAL FINDINGS IN MALES WITH HYPEROSTOSIS CRANII AS COMPARED TO NORMAL

Group	No. of Cases	Per Cent	Obesity		Goiter		Headache		Skull Trauma	
			No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Group I (Puberty)	186									
Hyperostosis cranii	5	3	0	0	0	0	0	0	0	0
Normal	181	97	3	2	0	0	0	0	1	0.4
Group II (Fertile)	119									
Hyperostosis cranii	3	3								
Normal	116	97								
Group III (Postfertile)	29									
Hyperostosis cranii	1	3	0	0	0	0	0	0	0	0
Normal	28	97	2	0.4	2	7.1	4	14	0	0

the thickening of the bone was caused by expansion of the spongiosa. A very interesting finding was the sharply delineated denser boundary zone observed in both cases in the structure of the spongiosa (Fig. 5A). Below this zone, towards the inner table, the spongiosa was more irregular and coarser but the bone trabeculae

were thinner than in other parts of the diploë. This boundary zone probably corresponded to the earlier location of the tabula interna before the hyperostosis had begun to form and the tabula interna had moved inward.

In the third case (Fig. 5B), the tabula interna was thick and fairly sclerotic both in the frontal bone and in the parietal bone. Its structure appeared normal and similar to that of the outer table. The spongiosa was fairly coarse in structure; the intertrabecular spaces were rather large and varied in size.

On microscopic examination the structure of the bone in the hyperostotic region was normal in appearance in all the cases, although in 1 case deep grooves could be seen in the inner surface of the tabula interna, apparently developing haversian systems of bone on the inner surface (Fig. 6). This was evidence that the bone was still growing.

DISCUSSION

The incidence of hyperostosis was by far higher in women than in men in the present series, as is also true for the series of other workers. Table VI gives the incidence of hyperostosis recorded for the larger series reported in the literature.

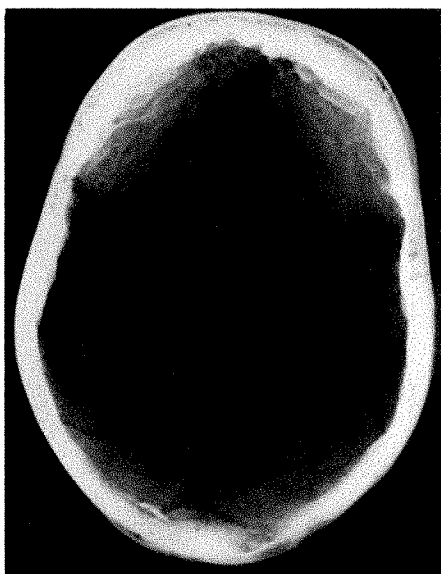


FIG. 4. Roentgenogram of detached skull cap (HFI proved at autopsy) reveals the nodular thickening of the frontal bone and some unevenness on the inner surface of the parietal bone.

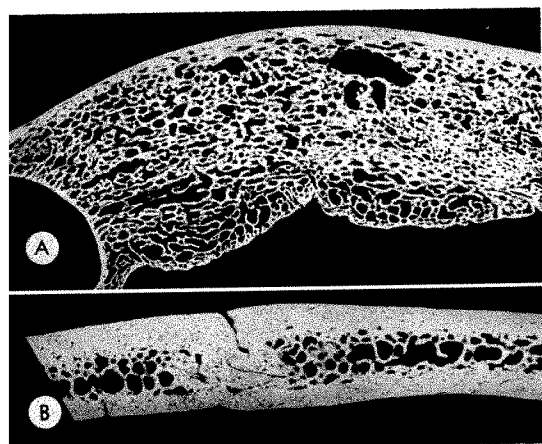


FIG. 5. Contact microroentgenograms of thin bony sections. (A) Frontal bone from a skull with HFL (the same case as in Figure 4). Note the boundary zone in the spongiosa structure. (B) Frontoparietal region of a skull with HFL.

The rather great variation in the percentage values obviously is due to two reasons: the selection of the patient material and the age classification adopted. The incidence found by us, in a normal population is of the same magnitude as that reported earlier in the literature, roughly corresponding to the mean figure of the different series.



FIG. 6. A photomicrograph of decalcified bone from the inner table of the frontal bone of a skull with HFL. On the surface of the bone there is a deep, regular, lamellar groove, apparently a developing haversian system.

In the females of the present series, 648 in all, headache was the only clinical symptom which seemed to be correlated with cranial hyperostosis. It was observed more commonly in the patients with hyperostosis, though it was not a complaint in all the cases, and was completely absent in the younger age group. In the postfertile age group obesity seemed also to be correlated; its incidence in cases of hyperostosis was

TABLE III

MENARCHE, MENOPAUSE AND PREGNANCIES IN FEMALES WITH HYPEROSTOSIS CRANII AS COMPARED TO NORMAL

Group	No. of Cases	Menarche Age (yr.)						Menopause Age (yr.)						Pregnancies	
		>12		12-16		<16		>46		46-50		<50		No.	Per Cent
		No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent		
Group I (Puberty)	146														
Hyperostosis cranii	10	0	0	10	7	0	0							0	0
Normal	136	0	0	136	93	0	0							0	0
Group II (Fertile)	249														
Hyperostosis cranii	43	1	2	35	82	7	16							41	95
Normal	206	5	2	188	92	13	6							197	96
Group III (Postfertile)	253														
Hyperostosis cranii	55	0	0	50	91	5	9	6	11	35	64	14	25	38	69
Normal	198	0	0	166	84	32	16	44	22	116	59	38	19	113	57

TABLE IV

INCIDENCE ACCORDING TO TYPE OF HYPEROSTOSIS
CRANII IN FEMALES

Type and Grade	Group I (Puberty)	Group II (Fertile)	Group III (Post-fertile)	Total
HFI I	6	9	21	36
HFI II	0	2	6	8
HCD I	0	17	11	28
HCD II	0	1	4	5
HFP I	2	9	3	14
HFP II	0	1	6	7
NF I	2	4	4	10
NF II	0	0	0	0
Total	10	43	55	108

TABLE V

INCIDENCE ACCORDING TO TYPE OF
HYPEROSTOSIS CRANII IN MALES

Type and Grade	Group I (Puberty)	Group II (Fertile)	Group III (Post-fertile)	Total
HFI I	2	1	0	3
HFI II	0	0	0	0
HCD I	3	1	1	5
HCD II	0	1	0	1
HFP I	0	0	0	0
HFP II	0	0	0	0
NF I	0	0	0	0
NF II	0	0	0	0
Total	5	3	1	9

four times that in the normal cases. Goiter, previous pregnancies and the age of onset and termination of ovarian function did not seem to be of significance.

Cranial hyperostosis develops gradually with age, as can be seen from the greater incidence in the older age groups. The histologic findings likewise indicate that thickening usually does not begin until some time after the termination of growth and ossification of the skull. An identical conclusion was reached by some other authors.^{7,9,16} According to Moore,²⁰ hy-

perostosis develops with advancing age and one form can change to another. It is conceivable that hyperostotic changes can also be regressive, since their incidence seems to diminish with very advanced age.

The higher incidence of hyperostosis in women after middle age has been generally recognized.^{16,20,22,23,26} It seems to reach its peak at 40-60 years, subsequently decreasing rather sharply. A similar age distribution in a large series was reported by Moore.²⁰ Although this higher incidence has been thought to be associated with the

TABLE VI

INCIDENCE OF HYPEROSTOSIS CRANII REPORTED IN THE LITERATURE

Author	Year	Total No. of Cases	Hyperostosis Cranii			Remarks
			Total Cases (per cent)	Females (per cent)	Males (per cent)	
Dressler ⁷	1927	1,632	4.4			Psychiatric series
Canavan	1938	3,250	7			
Richter ²⁶	1939	1,927	7.6			
Eldridge and Holm ⁸	1940	200	25			Psychiatric series
Grollman and Rousseau ¹²	1944	1,620	4.8			
Pedersen ²³	1947	908		9.75		Women only
Henschen ¹⁶	1949	2,000	19.9	36.9	0.9	
Moore ²⁰	1955	10,064	6.73	12.29	1.08	
Gershon-Cohen <i>et al.</i> ¹¹	1955	128	37	62	0	Inmates of homes for the aged
The Present Study	1960	982	12.2	16.7	2.7	

physical constitution,¹⁶ it is apparently of hormonal origin, an endocrine stigma.²³ Secretion of estrogen continues in about 50 per cent of women after the climacteric and then it diminishes gradually.²⁵ The greatest incidence of hyperostosis cranialis interna occurs at about the time of the climacteric and during the following 5-10 years. A direct correlation between estrogenic activity and hyperostotic skull changes is scarcely presumable, but it is quite possible that disturbance in the equilibrium of sex hormone production (estrogens, progestones and androgens) and of gonadotrophin production in the hypophysis at different ages of life may be a contributing factor. The role of the hypophysis and the adrenal glands requires further study. Caughey⁴ suggested that hyperostosis cranii is an acromegaloid feature related to gonadal hypofunction.

The ratio between the different forms of hyperostosis in the present series corresponds approximately to that reported by other workers. Frontal hyperostosis seems to become more common with advancing age, though there is no great difference in its incidence in the various age groups. The predisposition to headaches and obesity was identical in the different forms of hyperostosis, and there was no significant difference between the age groups.

The number of cases of hyperostosis in males was so small in the present series that it does not warrant any conclusions. The incidence, however, seems to be identical in the different age groups, around 3 per cent, which suggests that hyperostosis is a constitutional, fairly invariable feature in men.

SUMMARY AND CONCLUSIONS

Skull roentgenograms of 982 apparently healthy subjects, 648 women and 334 men, were studied. The series included three nonselected population groups: (1) girls and boys of 15-20 years; (2) women at the age of sexual maturity, most of them pregnant; and (3) postfertile women and old persons of both sexes. The series also included 119 men of different ages who had been examined for skull trauma.

Notation was made of previous illnesses and symptoms which might have been associated with cranial hyperostosis.

Hyperostotic changes of the skull were established in 117 cases, *i.e.*, in 12.2 per cent. The percentage for women was 16.7 and for men 2.7. Hyperostosis was most frequent in the women of postfertile age (22 per cent) and fertile age (17 per cent), but was distinctly less frequent at the age of puberty (7 per cent). Roentgen changes were established in less than 3 per cent of all the males.

Cranial hyperostosis develops gradually with advancing age. The histologic findings in hyperostotic skulls support this view. It is also possible that the hyperostotic changes can disappear, since the incidence seems to diminish in very advanced age. The possible correlation of the age distribution to sex hormone production is discussed.

Headache and obesity in the postfertile group were the only clinical findings correlated with cranial hyperostosis in this series. No correlation with goiter, previous skull trauma, the onset of menarche or menopause and the number of pregnancies was established.

To summarize these conclusions: cranial hyperostosis is a fairly common finding in completely normal females; in the male sex the incidence is low; it cannot be considered to be a pathologic process; in women it seems to cause or to be related to headache, especially at a later age; in all probability it is of hormonal origin and may be related to gonadal function, possibly to alterations in the interaction of the estrogens, androgens and gonadotrophins.

The many reports in the literature suggest that cranial hyperostosis is found in connection with many different illnesses and symptoms, but the causality is quite questionable because of the relatively high incidence of hyperostosis in normal populations, 12.2 per cent in the present material.

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HYPEROSTOSING MENINGIOMAS OF THE ASTERION*

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ALTHOUGH hyperostosing cranial meningiomas are common lesions, those involving the asterion are rare. They are not mentioned in the monumental work by Cushing and Eisenhardt² or in a large series of meningiomas reported by Olivecrona and Hoessly,⁶ Grant,³ Wickbom and Stattin,¹⁰ Rowbotham,⁸ Holub,⁵ Castellano and Ruggiero,¹ Pendergrass, Schaeffer and Hodes,⁷ or in the encyclopedias on cranial roentgenology.

Since the major portion of this tumor is at the junction of the suture lines of the temporal, parietal, mastoid, and occipital bones, the term "asterion" best describes the location.

The pathology underlying the hyperostosis has been thoroughly reviewed by Rowbotham.⁸ He quotes the views of Cushing and Eisenhardt,² Penfield and others that the new bone is not an integral part of the tumor but is reactive in nature and that the bony thickening is caused by invasion of meningioma cells with resulting stimulation of osteoblasts and the production of new bone.

The first case reported herein had intracranial extension of the tumor but the second had none. In neither was there direct involvement of the cranial nerves. In both, chronic headache was the main complaint and a rapid increase in tumor growth precipitated intracranial intervention.

REPORT OF CASES

CASE I. R.P., aged sixty-three, was admitted on March 9, 1949 with a history of generalized headaches for a period of twenty years and impaired hearing in the left ear due to otitis since childhood.

The neurologic examination showed bilateral choked disks. The cranial nerves were normal except for slight hearing loss on the left. There

was no loss of sensation or motor function and only mild impairment of coordination on the left. A firm mass extended over the left mastoid, temporal, lower parietal and occipital areas (Fig. 1, *A* and *B*). There was no bruit. The physical examination was negative. Blood calcium was 9.6 mg. per cent, phosphorus 4.5 mg. per cent, and the alkaline phosphatase 4.4 Bodansky units.

In the roentgenologic report by Dr. W. Edward Chamberlain on March 10, 1949 it was stated that the first examination in 1940 showed a diffuse "osteoma" involving the entire left mastoid area and temporal bone except the mesial portion of the petrous pyramid. The examination on March 10, 1949 revealed extension of the "osteoma" across the petrous bone to within 1 cm. of its mesial extremity and across the suture lines into the neighboring portion of the parietal and occipital lobe. The remainder of the skull was negative. Dr. Chamberlain felt that "In retrospect, although a simple benign osteoma must be considered, the most likely diagnosis would be that of a hyperostosing meningioma" (Fig. 2, *A* and *B*).

At operation on March 14, 1949, the huge bone mass was reduced by multiple burr openings and the remaining tumor mass involving the mastoid and the posterior portion of the petrous pyramid was removed. A biopsy of the soft tissue invading the mastoid and the dura revealed meningioma. A dural opening above and below the left lateral sinus exposed a firm subtentorial meningioma.

The transverse sinus was ligated and sectioned and a portion of the tentorium was resected together with the attached intradural tumor which lay in a nest on the superior surface of the cerebellum. Because of the benign nature of the tumor and the danger of facial paralysis, the remaining portion of the petrous bone was not removed.

In the pathology report it was stated that one specimen was bone measuring $8 \times 2\frac{1}{2} \times 1$ cm. and the other a mass of reddish brown tissue and dura measuring $5.5 \times 4 \times 2.5$ cm. (Fig. 3*A*).

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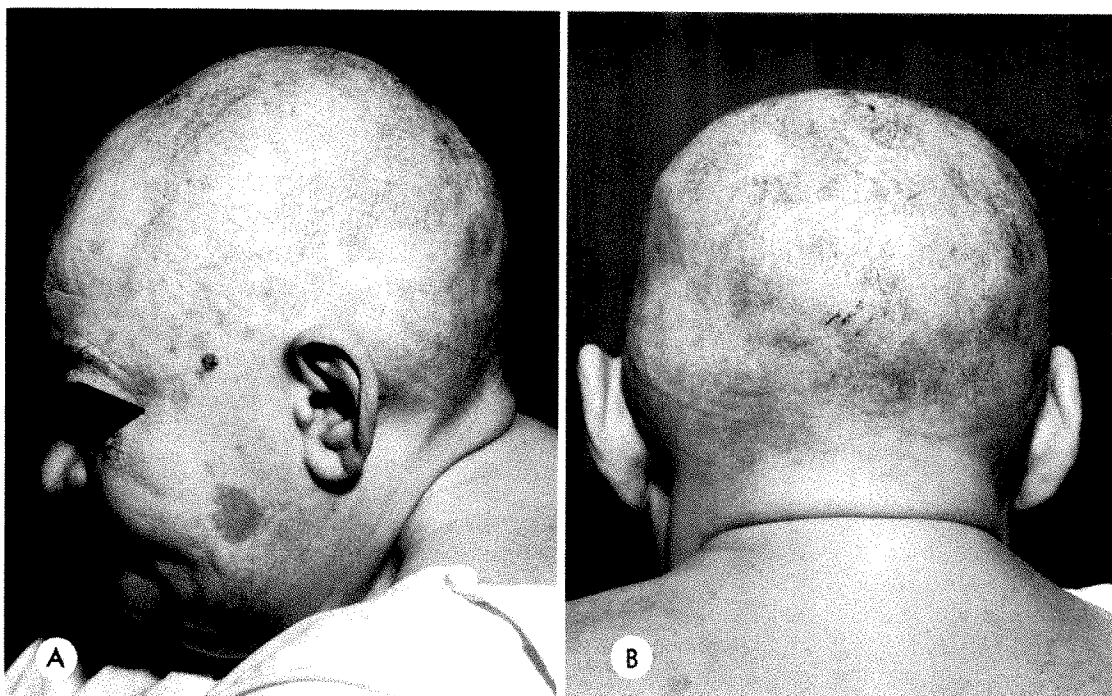


FIG. 1. Case 1. (*A* and *B*) Photographs showing the firm mass that extended over the left mastoid, temporal, lower parietal and occipital areas.

The tissues showed whirls of spindle cells surrounding vascular elements in some areas with psammoma-like features (Fig. 3, *B* and *C*). The diagnosis was meningioma—mixed psammoma and angiomatoid variety. The bone had whirls of fibrous elements similar to those seen in previously reported material and was eroded by the benign meningioma.

The patient made an uneventful recovery and was last examined twelve years later (February 24, 1961) at the age of seventy-five. She was comfortable and ambulatory. She still complained of mild headaches and impairment of hearing in the left ear. The decompression was soft. The neurologic examination was negative.

Roentgenograms on February 24, 1961 showed the large surgical defect. The remaining mesial two-thirds of the petrous bone demonstrated progressive sclerotic hyperostotic changes. The remaining skull showed no recurrence of the lesion (Fig. 2, *C* and *D*).

The microscopy of the tumor was reviewed by Dr. A. Peale who confirmed the previous diagnosis of meningioma.

CASE 11. J.K., aged forty-four, was admitted on March 31, 1951. He stated that in early

childhood a lump developed behind the left ear shortly after a blow to the area. This mass enlarged slowly for a period of twenty years and then rapidly for six months before admission. He had pressure headaches and impaired hearing on the left since childhood. The neurologic examination was normal except for a left congenital ptosis. Audiometric studies were negative for nerve deafness. The blood calcium was 10.6 mg. per cent, phosphorus 3.7 mg. per cent, and alkaline phosphatase 8.5 Bodansky units. A hard globular mass protruded behind the left ear (Fig. 4, *A* and *B*). There was no bruit.

Roentgenograms showed a lesion 5×8 cm. involving the squamous, mastoid, and posterior lateral aspect of the petrous portion of the left temporal bone and the parieto-occipital junction (Fig. 5, *A* and *B*). There was swelling, mainly externally but also internally, and replacement of normal structure resulting in a bulging of the inner and outer tables. The abnormal texture of the replacement substance showed a mottled appearance due to numerous calcium foci and soft tissue density stroma. The remainder of the skull was negative. The diagnosis which was considered was fibrous dys-

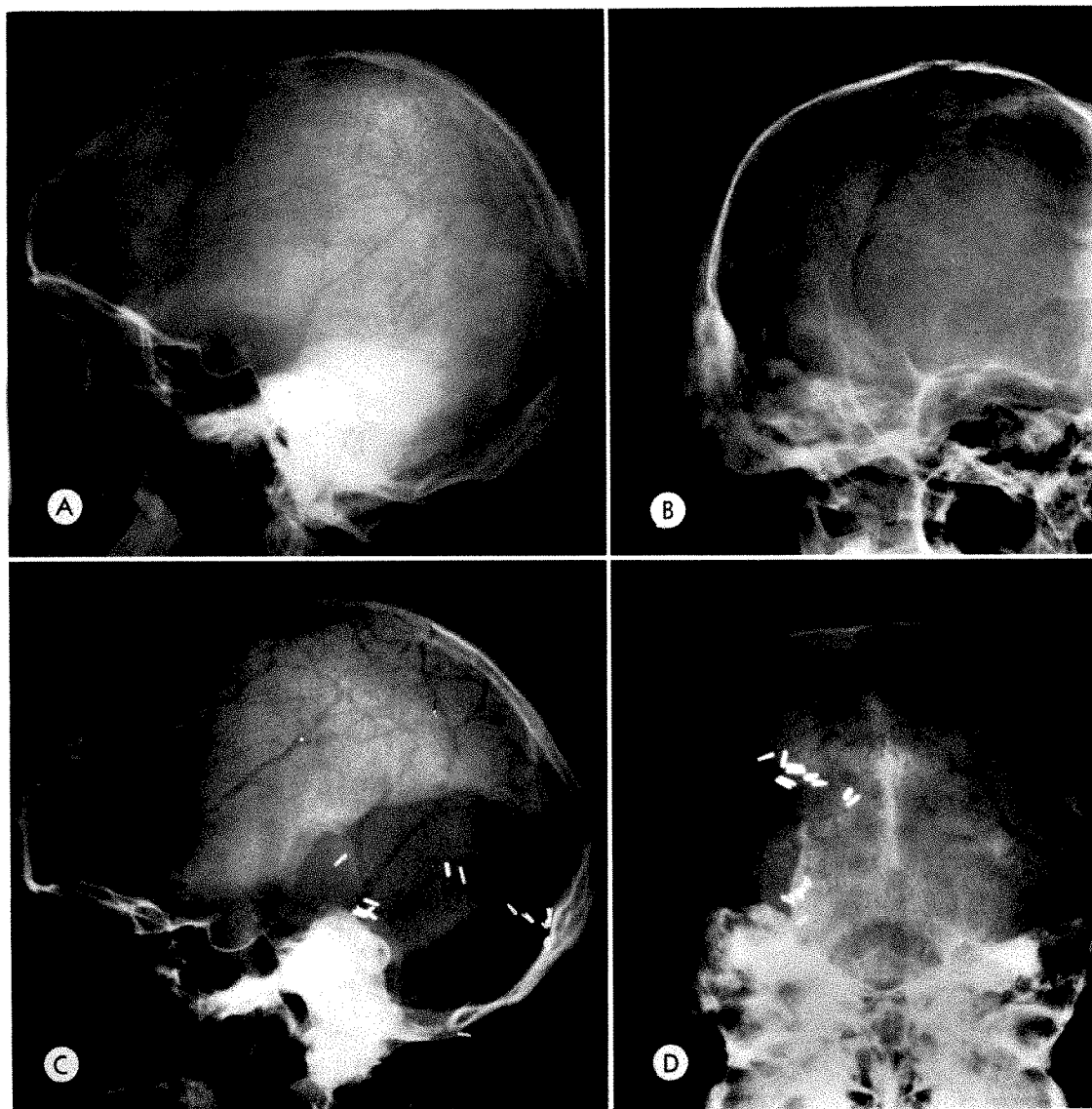


FIG. 2. Case 1. (*A* and *B*) Roentgenograms showing the hyperostosing meningioma involving the left asterion. (*C* and *D*) Twelve years postoperatively when the patient was seventy-five years of age, no recurrence was noted.

plasia. The increasing size of the lesion at this age raised the possibility of malignant changes. A meningioma was excluded. The skeletal survey was negative (Dr. Henry Woloshin).

At operation on March 2, 1951 the thick bony mass was honeycombed with multiple burr openings and the tumor was reduced. Upon breaking this tumor flap from the inner portion of the mastoid, the latter was found infiltrated by soft tumor tissue which was removed until normal bone was encountered. There was no intradural involvement (Fig. 6,

A, *B* and *C*). A stainless steel plate was inserted to cover the skull defect (Fig. 5, *C* and *D*). The patient had an uneventful convalescence.

In the pathology report it was stated that one specimen consisted of a mass of grayish-red soft tissue and a small fragment of bone. The second specimen was flat bone showing an area of swelling between the tables measuring 5.5 cm. in diameter. When sectioned, the bone tables were intact and the central portion was composed of gray mottled with yellow tissue (Fig. 6, *A* and *B*).

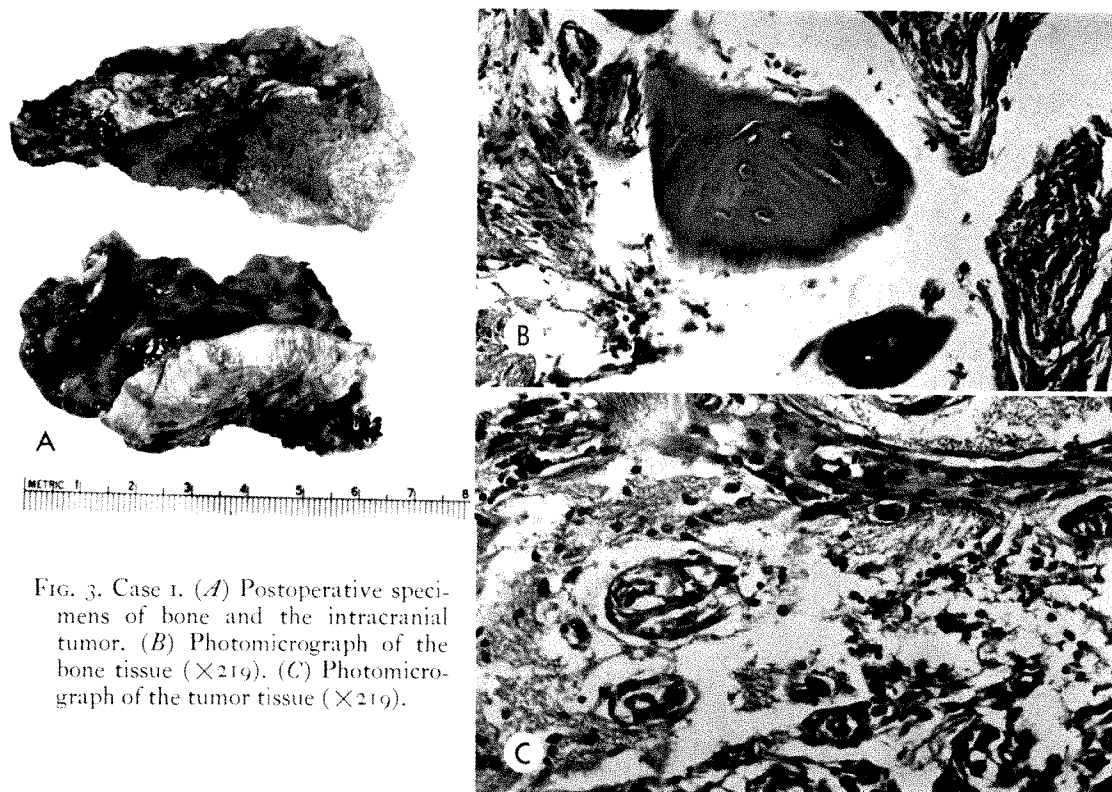


FIG. 3. Case 1. (A) Postoperative specimens of bone and the intracranial tumor. (B) Photomicrograph of the bone tissue ($\times 219$). (C) Photomicrograph of the tumor tissue ($\times 219$).

Microscopic examination (Fig. 6C) revealed a sheet of vascular fibrous tissue in which were seen focal areas of calcification. The fibrous tissue was made up largely of spindle-shaped cells consisting of eosinophilic cytoplasm with ovoid nuclei with, in many, a prominent nucleolus. These cells were arranged in intervening bundles; interspersed between these bundles were scattered leukocytes. Sections labeled bone flap and tumor showed an outer layer of bone with enlarged haversian canals. Within this bone and growing loosely into the enlarged canals were strands of fibrous tumor tissue similar to but more loosely arranged than that described above.

These specimens had the appearance of a meningioma of the fibrous type attached to and growing into the haversian canal of the bone.

The patient was last examined ten years after surgery. He was in good health and was still working as a chauffeur. He complained of an occasional headache but there were no complaints referable to the plate (Fig. 4, C and D; and 5, C and D). Neurologic examination was again negative, except for the slight congenital ptosis and the impaired hearing on the left.

Roentgenograms of the skull on February 16, 1961 (Fig. 5, C and D), ten years after operation showed the large craniotomy defect covered by a steel plate. The osseous structure around the plate was normal. There was no evidence of any erosive or destructive process. A review of the microscopic study of the tumor by Dr. Peale confirmed the previous diagnosis of meningioma.

SUMMARY

Two cases of hyperostosing meningioma of the asterion are reported. The first, in a female aged sixty-three, was associated with an intradural extension of tumor which involved the lateral transverse sinus and tentorium, compressed the superior lateral surface of the left cerebellum and produced increased intracranial pressure. The second, in a male aged forty-four, was limited to the bone and external layer of the dura.

In both, the lesion was present since childhood. In one it was first noticed after a blow to the area. In both, there was mild

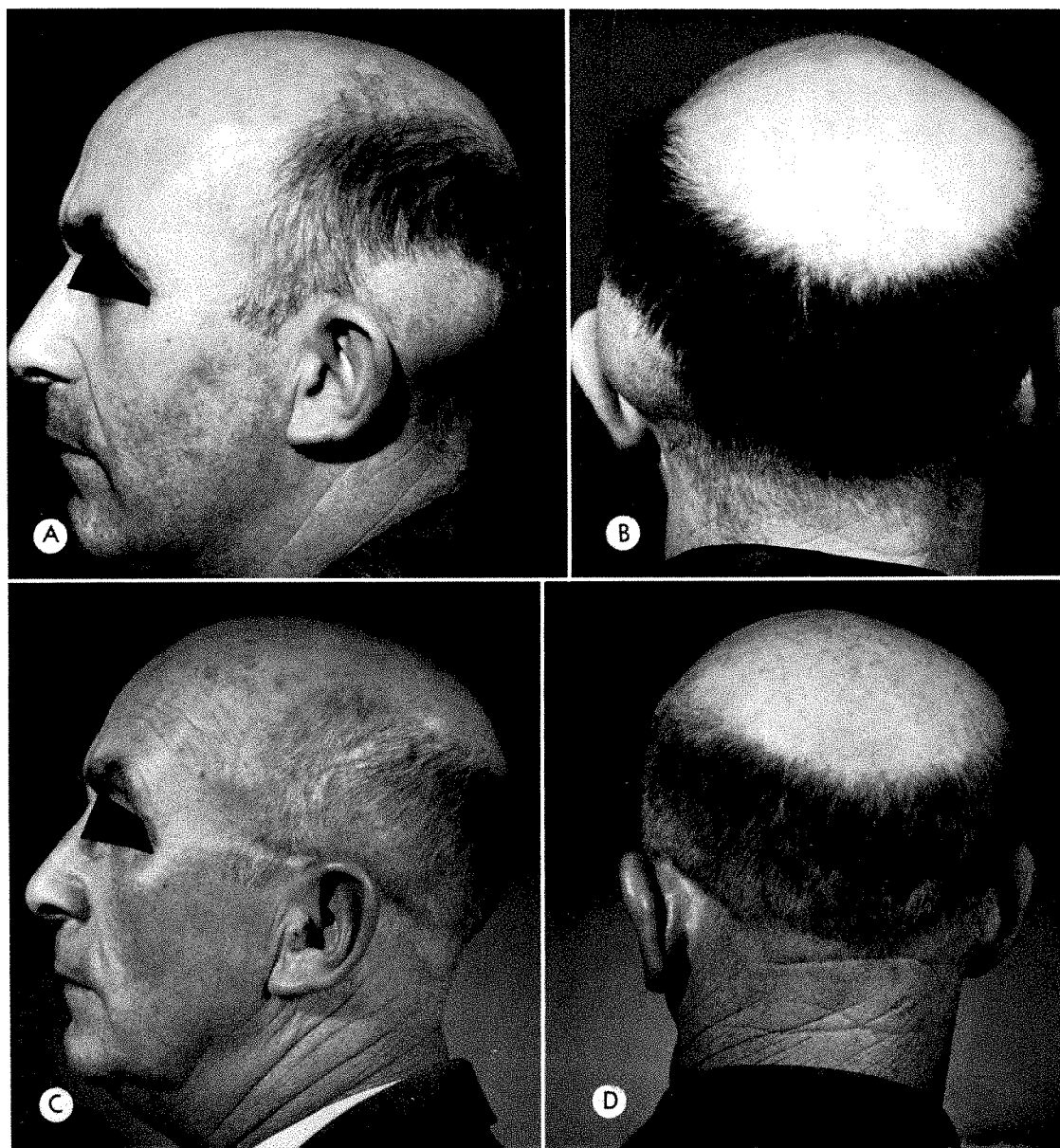


FIG. 4. Case 11. (A and B) Photographs showing the mass protruding behind the left ear. (C and D) Ten years postoperatively no recurrence was noted.

impairment of hearing on the involved side since childhood, but in neither was there any direct cranial nerve involvement.

An increased growth of the tumor, in one patient in the fifth decade and in the other in the fourth decade, necessitated surgical intervention.

One patient has been followed for ten

years and the other for twelve years and no recurrence has been noted in either case.

The unusual location of this lesion is stressed.

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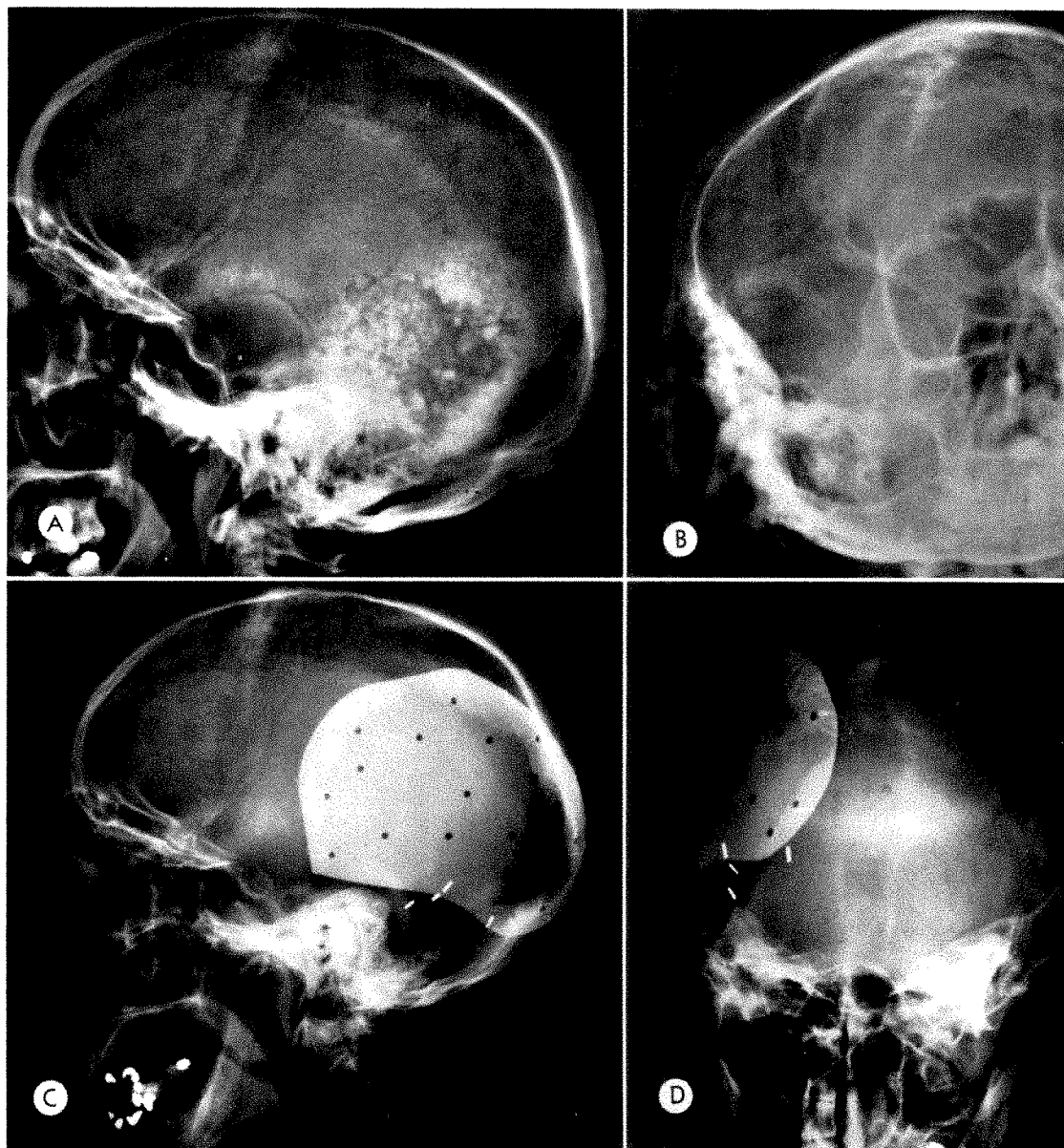


FIG. 5. Case 11. (A and B) Roentgenograms showing the hyperostosing meningioma involving the left asterion. (C and D) Ten years postoperatively no recurrence was noted and the steel plate appeared to be firmly placed.

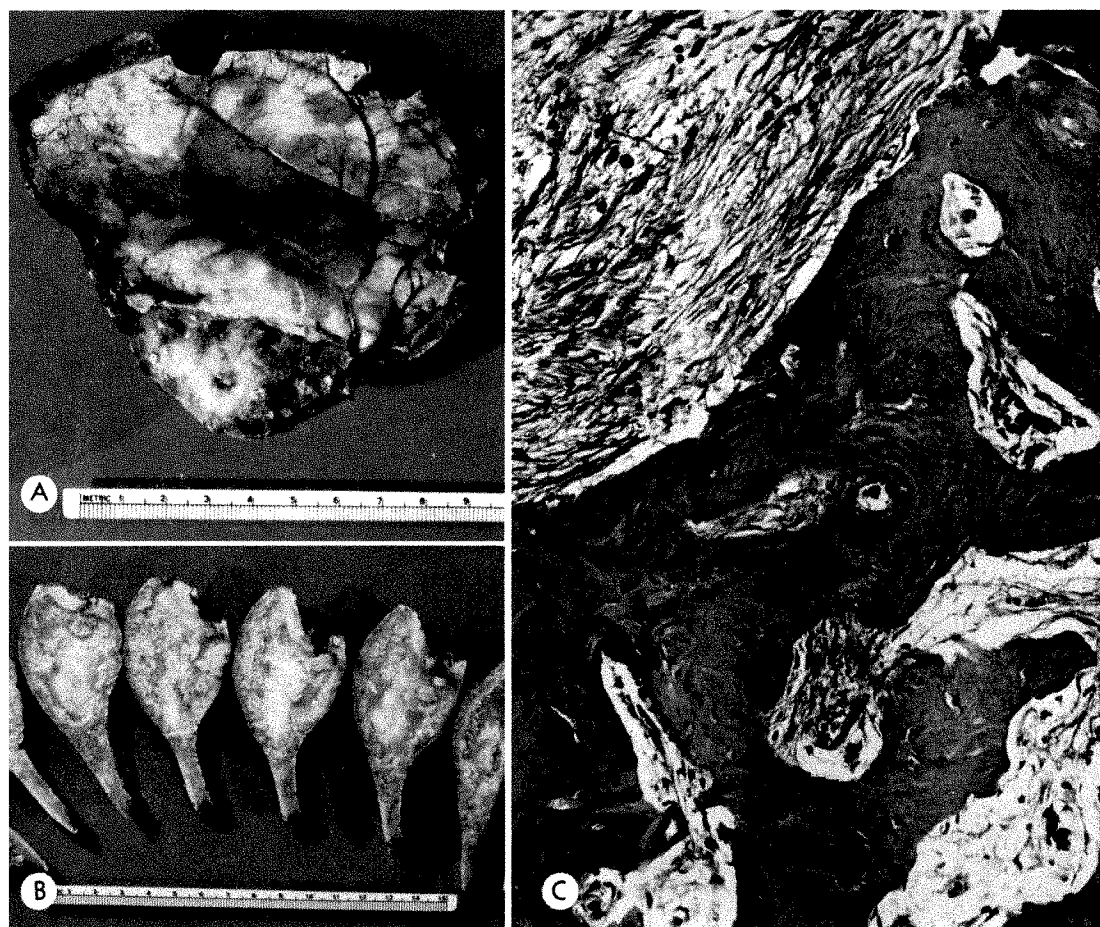


FIG. 6. Case II. (A and B) Postoperative specimens. (C) Photomicrograph of tissue.

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OSSEOUS ACTINOMYCOSIS OF THE HEAD AND NECK*

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A REVIEW of the literature shows that primary osseous involvement of actinomycosis in the head and neck is extremely rare. Sanford and Voelker,¹¹ reporting on all cases of actinomycosis occurring in the United States before 1925, found that 65 per cent occurred in the head and neck, yet not one case was found to involve the bones of the face or the jaw. Pendergrass, Schaffer and Hodes⁸ were unable to find a single instance of involvement of the facial bones although they did find that the paranasal sinuses might be affected.

Addition to the literature of the following 4 cases (2 involving mandible; 1 involving mandible, maxilla, mastoid, cervical spine, and ribs; and 1 involving maxilla) is therefore of importance in establishing a more comprehensive understanding of osseous actinomycosis.

REPORT OF CASES

CASE I. V.G., a 22 year old white female, presented with the chief complaint of pain in the left mandible. The only finding was an impacted lower left third molar, which was extracted.

Two months later, the patient developed acute onset of pain and swelling over the left jaw and inability to open her mouth. There was no regional lymphadenopathy and the patient was afebrile. The white blood cell count was 9,300. Roentgenograms of the mandible were negative. Examination revealed two discrete masses, one at the angle of the left mandible and the other anterior to it.

Roentgenograms 3 weeks later showed a sharply demarcated area of destruction lying between the condyle and the coronoid process without bone reaction (Fig. 1). The chest roentgenogram was normal. The intermediate PPD was positive.

Aspiration yielded about 3 cc. of purulent

material which did not grow in culture. The direct smear showed organisms of the *Actinomyces* type, although there were isolated areas of questionable acid-fast organisms which could have been of the *Nocardia* type. All symptoms and findings disappeared with penicillin and gantrisin treatment over a 5 week period.

Ten weeks later, on February 4, 1959, the patient returned asymptomatic. Roentgenograms made on April 24, 1959 showed slowly decreasing size of the lytic areas. Bone sclerosis was absent (Fig. 2). Complete healing associated with moderate subperiosteal bone formation and bone thickening was evident by July 1, 1960.

CASE II. E.K., a 23 year old Negro male, underwent extraction of the upper left second molar. Because of poor oral hygiene and low fever, his dentist gave him 600,000 units of penicillin daily for a period of 3 days. The patient's temperature continued to rise, however, and his white blood cell count was 32,000. There was gross swelling and extreme pain over the left face.

The penicillin was discontinued when the patient developed a skin rash and chloromycetin therapy was started. Fifteen cubic centimeters of dark purulent material were aspirated from the left maxillary sinus after which the sinus began to drain. Roentgenograms showed complete clouding of the left maxillary, ethmoid and frontal sinuses with soft tissue swelling over the left side of the face but no evidence of osteomyelitis (Fig. 3).

The left maxillary sinus continued to drain. Oro-antral and antrofacial fistulae developed and a direct smear taken from one of the draining fistulae at this time revealed *Actinomyces*.

A nasal antral window was opened and the sinus was repeatedly irrigated through this window with a solution of achromycin for a period of 3 weeks. At the end of this time, roentgenograms showed destruction of the floor of the left orbit with clouding of the left ethmoid cells (Fig. 4). The patient continued to

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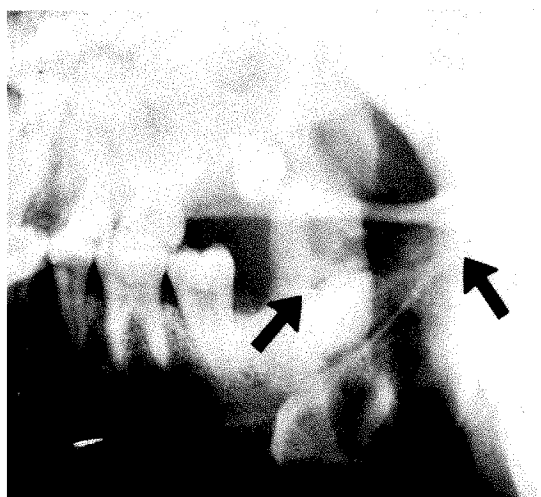


FIG. 1. Case I. October 22, 1958: A localized destructive area of bone extending between the base of the condyle and the coronoid process is present with irregular margins but rather sharply demarcated from the surrounding normal appearing bone.

gave drainage from his left maxillary sinus for 7 weeks, but was completely without symptoms at the time of his last visit one week later.

CASE III. R.W., a 36 year old Negro male, was admitted with multiple draining cervical and facial abscesses. Actinomycosis was diagnosed from direct smears. Roentgenograms revealed bony proliferation and marked sclerosis with several tiny areas of bone lysis involving the mandible (Fig. 5). The left maxilla and

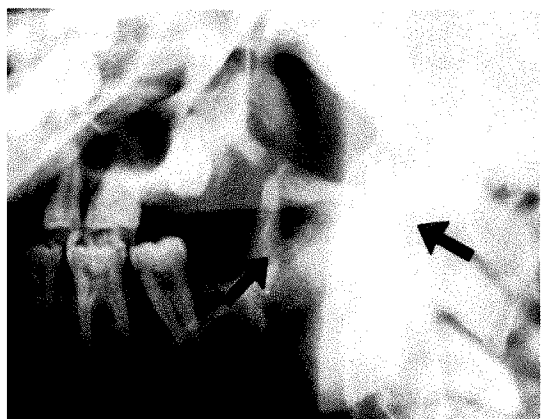


FIG. 2. Case I. April 24, 1959: Partial healing of the osseous defect in the mandible has occurred as indicated by the decrease in the size of the bone defect. Prominent by its absence is bone sclerosis which cannot be recognized at this time, 4 months after bone destruction was first demonstrated.

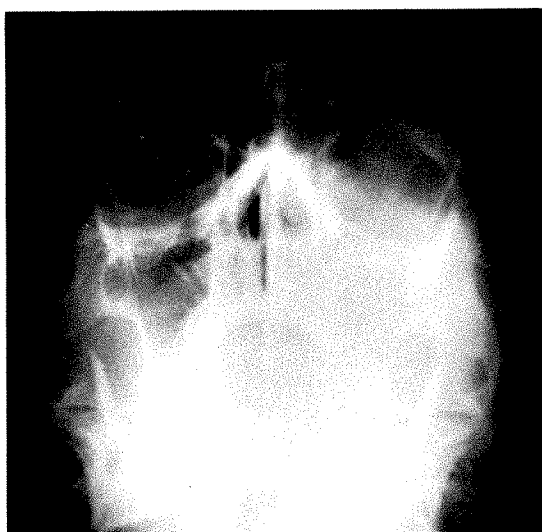


FIG. 3. Case II. September 29, 1958: Marked sinusitis involving the left maxillary antrum and ethmoid sinuses is present and associated with considerable soft tissue swelling over the left side of the face. There is no evidence of bone destruction at this time.

mastoid showed similar reactive sclerosis. A destructive lesion with mild reactive sclerosis but without subperiosteal reaction was seen in the first left rib and lateral portions of the upper



FIG. 4. Case II. November 17, 1958: The infectious process has progressed with marked destruction of the floor of the left orbit and destruction of the left maxilla, but with no significant bone reaction. The increased density over the left maxilla and zygoma appears to be due to soft tissue swelling.



FIG. 5. Case III. An oblique roentgenogram of the left mandible showing the marked osteoblastic reaction of the jaw and the resultant thickening and sclerosis of the left mandible.

cervical vertebrae (Fig. 6). There was increased density over the apex of the left lung due to pleuritis and localized thickening and overlying edema of soft tissues. No definite pulmonary infiltration was seen. A small area of infiltration was noted in the right upper lobe with an appearance that suggested fibrosis, but active infiltration could not be ruled out. Drainage of the cervical facial lesions produced pure *Actinomyces*. He was treated with penicillin for a period of 8 weeks. Five weeks later he was still on gantrisin, although he was considered a clinical cure. No further follow up was available.

CASE IV. J.W.B., a 39 year old white male, was admitted in 1955 for recurrent carcinoma of the skin of the nose. He had a history of having had 15 skin carcinomas of the face, primary or recurrent, since 1945 when a carcinoma of the lower lip was removed. As far as can be determined, he had never received radiation therapy.

He was referred to the Dental Service because of his poor dental condition and dental roentgenograms showed honeycombing of the mandible below an empty tooth socket. Additional roentgenograms of the mandible were made and revealed several poorly demarcated irregular areas of bone destruction of the mandible, some apparently interconnected,



FIG. 6. Case III. Mottled sclerotic change is seen in the cervical spine, most marked on the left, and in the left first 2 ribs. Also seen on this roentgenogram is the osteoblastic reaction involving the left mandible, maxilla, and mastoid.

associated with minimal reactive bone (Fig. 7). A normal bone pattern was seen in the unaffected surrounding bone.

A biopsy revealed the presence of *Actinomyces* but no positive culture was obtained. He was treated with 100 mg. of INH*t.i.d. over a period of 10 weeks with resultant complete healing.

The patient has been seen several times since then for other complaints, his last visit having been in March, 1961. There has been no recurrence of the infectious process of the jaw.

GENERAL DISCUSSION

Of the *Actinomyces* group, the organism responsible for infection in man is *Acti-*

* An Isoniazid preparation by Eli Lilly and Company.



FIG. 7. Case IV. Oblique roentgenogram of the left mandible showing several interconnecting lytic areas of bone destruction associated with patchy, mild osteoblastic reaction.

nomycetes israeli.⁶ It remains latent about the gums and tonsillar crypts, causing infection only when the normal epithelial surfaces are broken so that the organism is allowed to invade. This is the commonest source of the infection according to Cope⁴ who points out that the organism has never been found on straw, hay, grasses or grains and that the disease is no more common among farmers than in city workers. The organism may also enter through the intestinal tract after being swallowed or through the lung after being inhaled.²

The carious tooth or dental trauma is the usual source of infection. In 3 of these patients, there was a history of a recently extracted tooth at the site of involvement, while Case III had a "poor dental condi-

tion" but no extraction. The infection was mild, slowly progressive and chronic and responded very slowly to therapy. The patients were afebrile or had only low grade fever. The laboratory findings were not significant and the roentgenograms were not diagnostic. An exact diagnosis was made by recognition of the organism on microscopic smear. Secondary infection may obscure the clinical and laboratory findings, however; the need for high grade suspicion of actinomycosis and perseverance in efforts to demonstrate the fungus is illustrated best by Case II.

The organisms penetrated into the tissues initiating an infection which was slowly progressive and chronic. Sinus tracts are usually present but developed and discharged pus in only 2 of the 4 cases presented. The slow progression and striking chronicity of these infections are illustrated in the first 3 cases.

According to Cope,⁴ actinomycosis is a disease often misdiagnosed due apparently to the fact that diagnostic reliance has been placed on agglutination, complement fixation, estimation of the opsonic index, precipitin test, and the skin test, all of which have been found to be unreliable. A positive diagnosis should be made from cultures and from identification of sulfur granules and the *Actinomyces* on smear.

The treatment of choice at present is the use of one of the sulfonamides and large parenteral doses of penicillin over a long period of time in addition to adequate drainage. Yow¹⁵ ordinarily uses both penicillin and the sulfonamides for about 3 months and then continues the sulfonamides for 3 more months. He warns that earlier attempts to discontinue treatment are associated with relapses. One of the 4 cases presented did very well on INH.

The prognosis in actinomycosis of soft tissues on proper, long continued therapy is very good. Very little is known about the prognosis of osseous actinomycosis, but the indications from the presented cases suggest that the prognosis for complete healing is good.

ROENTGENOLOGIC DISCUSSION

Osteomyelitis caused by actinomycosis is relatively uncommon and very few cases have been recorded in the literature. When the soft tissue infection extends to the periosteum, it causes a periostitis which may result in considerable subperiosteal new bone formation. This may be the only roentgenographic effect on the bone if the infection progresses slowly enough but, with a more rapid process, the bone is invaded with localized areas of bone destruction and caries formation, sometimes multiple, and often connected by sinus tracts^{4,5,7} and usually surrounded by increased bone density. Osteoblastic reaction may or may not be seen initially but usually does occur in later phases of the disease. In the mandible, there rarely occurs a large bony tumor formation; at other times, rarefaction may predominate and give an appearance of a smooth-walled cavity.

The mandible, ribs and spine are the commonest sites of osseous actinomycosis. Rib and spine infections are almost always secondary to direct extension from pulmonary or mediastinal involvement and bone destruction, often with intense secondary sclerotic reparative process, results (Fig. 6).^{5,6,7,12,13}

The mandible is involved by direct extension from soft tissue infection in the mouth. Rarely the infection of bone is embolic, in which case an intraosseous granuloma forms and is accompanied by considerably less subperiosteal bone reaction.^{5,10}

Of the 4 cases presented here, the first and second patients showed bone destruction with no initial osteoblastic reaction. The third demonstrated marked diffuse osteoblastic reaction with thickening and sclerosis of bone. In the fourth, there were lytic areas in the mandible with minimal scattered osteoblastic reaction.

Considerable soft tissue swelling was present over the area of bone involvement and, in some cases, this swelling contributed to the roentgenographic density of the underlying bone structure. All

osseous reactions took place at a very slow pace with several months elapsing before there was any significant change.

Osseous reaction to fungus infections is most often less than that expected with the usual form of osteomyelitis seen in bacterial infections such as *Staphylococcus* and *Streptococcus*, but the appearance may be identical.

Several factors may affect this response to infection: (1) flat bones are likely to respond with less reactive bone formation than are long bones; (2) antibiotics may decrease bone reaction to both bacterial and fungus infections; (3) secondary infection, too, may alter the bone picture in actinomycosis with greater bone formation resulting. On the other hand untreated low grade bacterial infections may stimulate little bone formation; and (4) the variation in reactive bone formation is also affected significantly by the duration of the infection. This is well illustrated in Case 1 in which a lytic area of destruction was present without bone formation for many months but finally bone thickening and sclerosis developed.

The response of bone to actinomycosis appears to depend in large part on the manner of involvement. Thus, rare embolic extension results in lytic lesions with little bone reaction, while direct extension to bone, which is the usual manner in actinomycosis, causes more periosteal reaction and bone sclerosis.^{5,10}

Of the fungus infections, actinomycosis usually gives the most marked osteoblastic reaction,² particularly when it is the result of direct extension and is slowly progressive. At the other end of the scale of osseous reaction is cryptococcosis, which usually causes little or no bony reaction.³ Lying somewhere in between these two variations of bone reaction are those due to blastomycosis and coccidioidomycosis. However, the differences between the fungus diseases are not simple and clear-cut and, in fact, they may all resemble each other very closely. Actinomycosis occasionally may have no reaction around the area

of bone involvement, especially early, while blastomycosis and coccidioidomycosis may show considerable osteoblastic and subperiosteal bone response. In the presence of marked new bone formation, cryptococcosis can probably be excluded but, when there is mild or absent bone reaction, none of the fungi or bacterial infections can be differentiated roentgenographically.

The osseous lesions of blastomycosis have been well described by Potter⁹, while those of coccidioidomycosis are well analyzed by Carter² and by Taylor.¹⁴ Collins³ has presented a most comprehensive analysis of osseous involvement by cryptococcosis.

It should always be remembered that actinomycosis may be simulated by tuberculosis in bone as well as in the lungs.

CONCLUSIONS

1. Contrary to the majority of opinions expressed in textbooks, a history of farm environment and injury of the oral mucosa by straw or grass are not needed for a provisional diagnosis of actinomycosis of the jaw. More important is the history of a recently extracted tooth.
2. A high grade suspicion and perseverance in efforts to demonstrate the fungus are necessary to arrive at the correct diagnosis in any infection of the jaw which does not respond promptly to therapy.
3. The roentgenographic appearance is not diagnostic but chronicity and relative lack of bone reaction are suggestive.
4. Although soft tissue infection by actinomycosis is not infrequent, bone involvement is uncommon.
5. Osteomyelitis due to actinomycosis is a low grade, slowly progressive, chronic infection which responds slowly to antibiotic therapy.
6. The roentgenographic appearance of involved bone may vary from lytic destruction without bone formation to marked thickening and sclerosis. Roentgen examination alone does not ordinarily permit differentiation of actinomycosis from infection caused by other organisms.
7. The prognosis of properly treated osseous actinomycosis is good as suggested by the presented cases.

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CINEROENTGENOGRAPHIC STUDIES OF PATIENTS WITH CERVICAL SPINE FUSION*

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IN THE field of radiology, the application of cineroentgenography has produced interesting observations. One such finding, reported previously, was the detection of a free range of motion in many patients wearing cervical collars.¹ Vertebrae of the cervical spine that on roentgenograms appear fused now can be shown to have motion between them.

Forty-one of the patients studied cineroentgenographically at the University of California Medical Center, San Francisco, have had parts of their cervical spines fused by spondylitis, peripheral rheumatoid arthritis, trauma, surgery, or congenital abnormality. This report deals with the detection of motion at the levels of these fusions.

METHOD

The manner in which the studies were conducted has been described previously.² A standardized position-motion technique and commercially available cineroentgenographic equipment were used in all patients. Only those findings that were observed on at least two separate viewings were considered valid. On reviewings, the observer did not know the results of previous interpretations.

MATERIAL

Of approximately 300 patients studied by cineroentgenography, 41 had some form of fusion of the cervical spine. In this study, a "unit" consists of one intervertebral disk with its adjoining vertebral bodies and their apophyseal joints. The number of fused units varied, from only one unit being involved to almost complete fusion of all cervical vertebrae. No fusions between the first and second cervical ver-

tebrae were seen in this group and, consequently, this unit was not considered in the analysis of results. The total number of units analyzed was 246, only 6 units of each patient being included.

Seven patients with ankylosing spondylitis or peripheral rheumatoid arthritis had fusion of 15 units (Table 1). Three of these 7 had changes not ordinarily associated with rheumatoid disease. One of these 3 had had an anterior interbody fusion operation and the findings are included in that category. In the other 2, the appearance of the fusion suggested congenital, rather than inflammatory origin and the data on these, therefore, are presented in the congenital category. In a fourth patient peripheral rheumatoid arthritis involved the spine and 3 others had classic roentgenographic changes of ankylosing spondylitis.

One patient, with 1 fused unit, had had a cervical injury at a much earlier date. The fusion appeared to be the end-result of a previous dislocation.

Five patients with 16 fused units had had posterior surgical fusions of from 1 to 5 cervical units.

Twenty-two patients had had fusion operations by the anterior interbody technique five to thirty months prior to study. One of these patients also had an apparently congenital fusion at another level.

Routine roentgenograms were available on 34 of the 41 patients at the time of final study. Patients without plain roentgenograms at the time of the last cineroentgenographic study included: 1 patient in whom the fusion was considered to be of congenital origin and no motion was detected; a second patient who had undergone anterior interbody fusion operation at 2 levels

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TABLE I

CINEROENTGENOGRAPHIC ANALYSIS OF RESIDUAL MOTION IN FUSED CERVICAL SPINE SEGMENTS

Type of Fusion	No. of Patients	No. of Units Involved	Failure of Fusion	Motion Noted in Apophyseal Joint	
				Left	Right
Rheumatic spondylitis and arthritis	4	15		6	1
Posterior	5	16	5	5	
Congenital	9	11			1
Traumatic	1	1		1	
Anterior interbody	23	44	14	23	3
Total	42*	87	19	35	5

* In 1 patient, anterior interbody fusion was performed on 2 other units.

and in whom fusion was obviously lacking at both levels; a third patient with anterior interbody fusion operation at 3 levels in whom failure of fusion was apparent at 1 level, leaving 2 units for analysis; a fourth patient who had had an anterior interbody fusion operation of 2 units, four months prior to study; a fifth patient with an anterior interbody fusion operation who had no motion at 1 of the 2 fused units; 2 other patients, each with anterior interbody fusion operation of 5 units with motion through 4 units.

Thus, in the total of 20 units analyzed by cineroentgenography, without plain roentgenograms, motion was not detected at 4 levels and 3 levels showed obvious failure of fusion. Substantiation of fusion by means of plain roentgenograms, therefore, was not available in 13 units where motion was occurring through fused units.

One patient also had laminagrams to demonstrate the intactness of fusion. In 1 other patient who apparently had a successful posterior fusion operation, motion between the vertebral bodies was demonstrated at operation for anterior interbody fusion.

RESULTS

ANKYLOSING SPONDYLITIS

In 1 patient, no mobility of the fused units was demonstrated cineroentgenographically. In 2 patients, isolated fused

units had the appearance of a congenital fusion and no motion was detected here. One patient who also had had an isolated, anterior interbody fusion operation at 1 level showed motion at this level with obvious lack of fusion. In 2 patients, there was extensive bridging of the lower 4 and 5 cervical units, respectively. In these, motion could not be demonstrated between the vertebral bodies or the right apophyseal joints, but minor motion was observed to occur through the left apophyseal joints.³

CONGENITAL FUSION

Of 7 patients with apparently congenital fusions, motion at the site of fusion was detected in only 1.

POST-TRAUMATIC FUSION

In the 1 patient studied, 1 cervical unit was involved and motion was detected through the apophyseal joint of one side.

POSTERIOR SURGICAL FUSION

Of the 5 patients who had had this operation, 2 demonstrated minimal mobility between the vertebral bodies at the sites of one- and two-unit fusion. In a third patient, the fusion operation involved 4 units and motion was suggested through the most cephalad of these. One patient with a four-unit fusion operation showed motion at 2 levels through the apophyseal joints. The fifth patient demonstrated pseudo-arthritis with persistent motion.

ANTERIOR INTERBODY SURGICAL FUSION

These patients comprised the largest group, reflecting the current interest in this approach to problems of the cervical spine. The number of units involved in any one patient varied from 1 to 4. In the 7 patients with single-level fusions, motion was detected through the apophyseal joints on at least one side in all patients, and in 1, obvious lack of fusion was present.

Similar motion was recorded in the 9 patients with two-level fusions. Failure of fusion was detected at 7 of the 18 units in which a surgical procedure had been performed.

In the 5 patients with three-unit fusion operation, comprising a total of 15 units, motion was detected at the superior and inferior levels, but not conclusively identified at the mid-unit in 1. Six of the other 12 units showed failure of fusion, in 1 patient at all 3 levels. One patient lacked fusion at 2 levels and had motion through the third fused unit. One patient without fusion at 1 level had residual motion at the other 2 levels. In the fifth patient, in spite of apparent successful fusion, motion occurred through the left apophyseal joints.

In most cases, motion was more clearly evident on the left than on the right. The range of motion varied from barely detectable to the limited amount frequently seen in degenerative disk disease. In 1 patient with degenerative disk disease, who had had an anterior interbody fusion, the amount of motion before and after operation was approximately the same.

DISCUSSION

The frequency with which motion is observed is of less interest than that it can occur through apparently solid bony union. Previous studies utilizing only routine roentgenograms with bending have indicated residual mobility in the lumbar spine. This motion was thought to represent some elasticity of bone.⁴ Contrary to Sgrosso's speculation, anterior interbody fusion is apparently less effective in reducing mobility than posterior fusion. Mo-

tion through the apophyseal joints on at least one side, despite apparent solid bridging between the vertebral bodies, implies that the inherent forces are sufficiently strong to bend the bony bridges. No correlation was shown in the postoperative group between detectable motion and the clinical status of the patient. Of the 22 patients who had undergone anterior interbody fusion operation, 5 were asymptomatic regardless of the degree of motion, 3 were definitely improved, and 13 had either persistence of complaints or recurrence of symptoms after a period of relief. One patient with an obvious failure of fusion had been completely relieved of symptoms.

All 5 of the patients with posterior fusions were symptomatic. They were referred for evaluation of symptoms rather than for study of effectiveness of the fusions. In 1 of the patients with isolated, single-unit posterior fusion, subsequent anterior interbody fusion relieved the symptoms.

The motion occurring through the apophyseal joints of ankylosing spondylitis correlated with the side of symptoms. The number of patients observed (2) was too small to judge whether this observation could be reproduced.

Interestingly, the motion took place primarily through the left apophyseal joints (Table 1) and occurred whether the grafts were placed in the midline or slightly to either side. No attempt was made to assess the degree of motion, but it appears that peripheral bony bridging between vertebral bodies allowed a somewhat greater degree of motion than did central fusion.

SUMMARY

Cineroentgenographic studies of the cervical spines of 41 patients, comprising a total of 246 units, were conducted. Of these 246 units, 87 had had some form of fusion. In 40 fused units, motion was noted. Obvious lack of fusion was present in 19 additional units. Motion was most markedly reduced by fusion of presumable congenital origin and the least reduced by anterior

interbody fusion. No correlation of motion with symptoms was found except in those patients with ankylosing spondylitis.

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SUBPERIOSTEAL EROSION OF THE RIBS IN HYPERPARATHYROIDISM*

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THE clinical, pathologic, and roentgenologic changes observed in hyperparathyroidism have been reported previously.² Since then, marked subperiosteal resorption along the upper margins of some ribs was incidentally noted on a roentgenogram of the esophagus of a patient with a parathyroid adenoma (Fig. 1, *A* and *B*). This finding prompted re-examination of the roentgenograms of several hyperparathyroid patients, with particular attention directed to erosive lesions of the ribs.

MATERIAL

Chest and rib roentgenograms of 33 patients with proved parathyroid adenomas were reviewed. Sixteen of these patients had roentgenologic changes typical of hyperparathyroid bone disease.

ROENTGEN FINDINGS

In 6 of the 16 hyperparathyroid patients with bone changes elsewhere, we also found shallow, more or less extensive defects of several ribs. The defects were located in the posterior or posterolateral portions of the ribs along their upper cortical margins. These findings were definitely distinguishable from the shallow indentations seen along the upper margins of some ribs in

healthy individuals (Fig. 2, *A* and *B*). Their characteristic, somewhat fuzzy border (Fig. 3, *A-F*) was similar to the indefinite cortical surface of the middle phalanges of the hands resulting from subperiosteal resorption. We feel, therefore, that the areas of radiolucency described represent local subperiosteal resorption along the upper margins of the ribs.

We have found these changes most frequently at the level of the third and fourth ribs, less commonly at lower levels. Usually the lesions were unilateral, but occasionally, the changes were bilateral at the same level, especially along the third and fourth ribs. The extent of the resorption varied. In one patient, the rib shadow was indiscernible in its posterior portion on roentgenograms taken in different positions (Fig. 4, *A* and *B*).

Patients with parathyroid adenoma who had no roentgenologically demonstrable bone disease elsewhere also did not show these changes in the ribs.

DISCUSSION

Defects along the lower borders of the ribs have often been described as manifestations of different disease processes. Reports regarding changes of the upper bor-



FIG. 1. (*A*) Erosive changes along the upper borders of the right third rib, less marked in the left third and fourth ribs posteriorly, incidentally noted on roentgenograms of the esophagus. (*B*) Diagram of *A*.

* From the Department of Radiology, University of California, School of Medicine, San Francisco, California. Aided by a grant from the United States Public Health Service, Grant A-2589 GM.

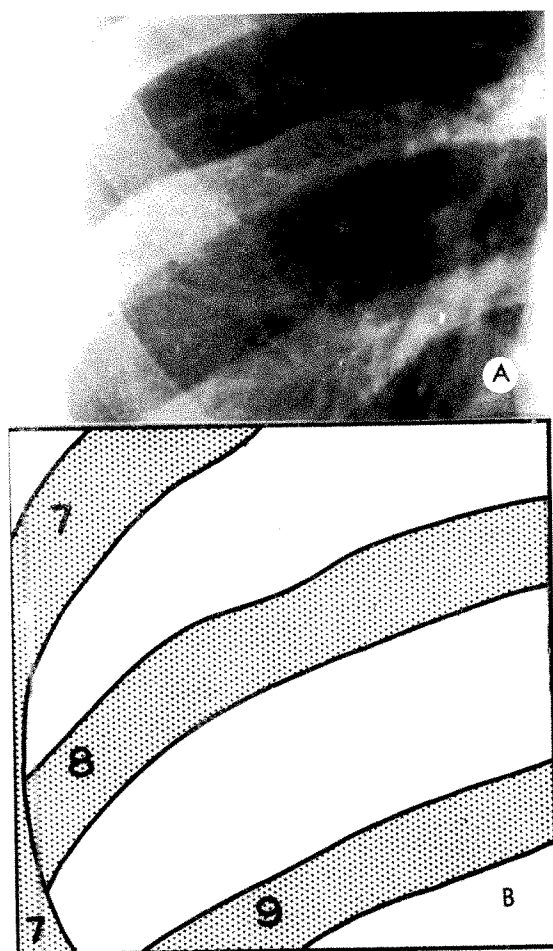


FIG. 2. (A) Shallow indentation of posterior aspect of eighth right rib as often seen in healthy individuals. Note sharp cortical margin. (B) Diagram of A.

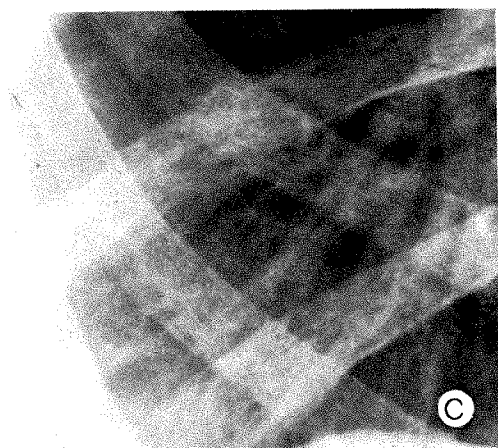


FIG. 3. (C) Short, shallow erosions of right ninth rib. (D) Diagram of C.

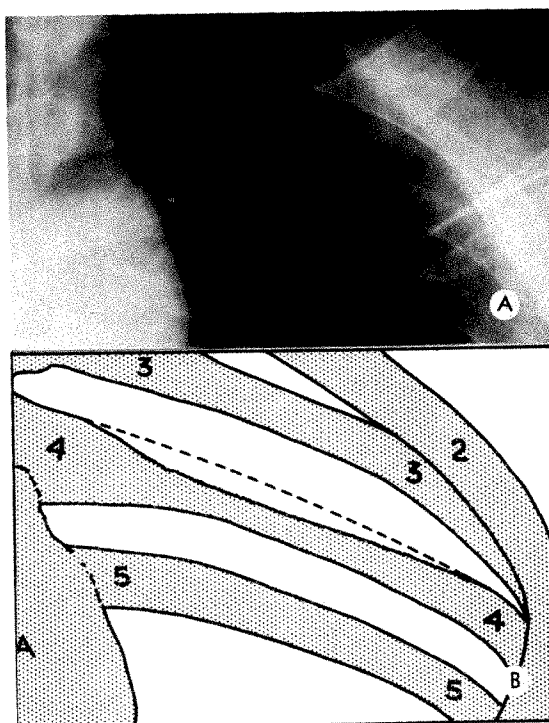
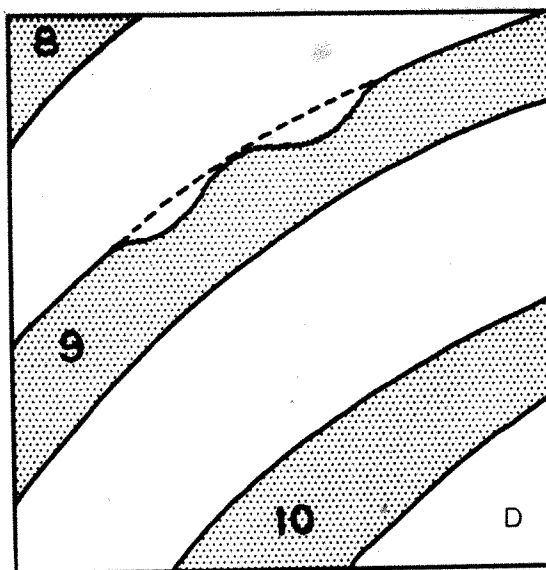


FIG. 3. Varying extent of erosion of the upper cortical rib margin. Note fuzzy outline of lesions. (A) Shallow, long erosion of left fourth rib. (B) Diagram of A.



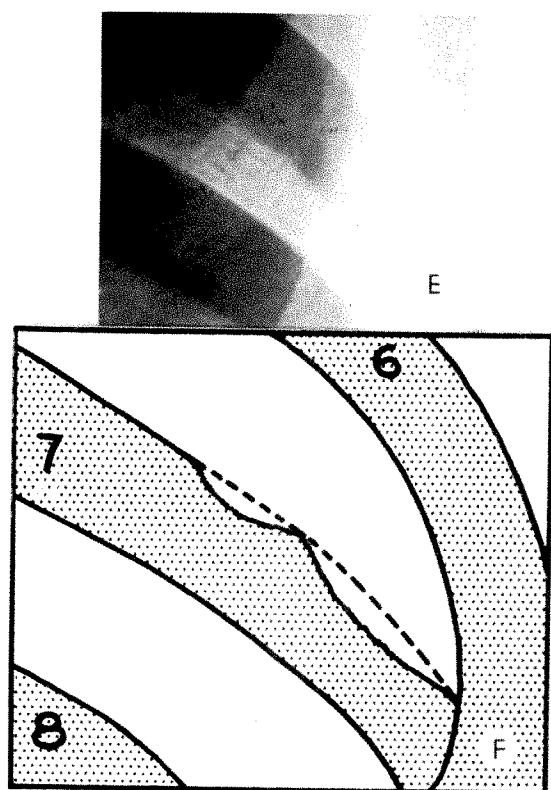


FIG. 3. (E) Short, slightly deeper erosion of left seventh rib. (F) Diagram of E.

ders are less common. In 1958, Bernstein *et al.*¹ described erosive lesions of the upper cortical margins of the ribs in patients with paralytic poliomyelitis. The rib changes in some of our patients resemble those reported by Bernstein *et al.* In other cases, however, the lesions in hyperparathyroidism are more shallow and longer, and their outline less definite. In both groups the distribution of the involvement is somewhat similar.

From our observations, it appears that cortical erosion of the ribs is not a common finding even in patients with marked bone changes from hyperparathyroidism. The lesions also do not seem to be specific as we have observed similar rib erosions in a patient with long-standing, markedly disabling rheumatoid arthritis who had received cortisone therapy over a long period

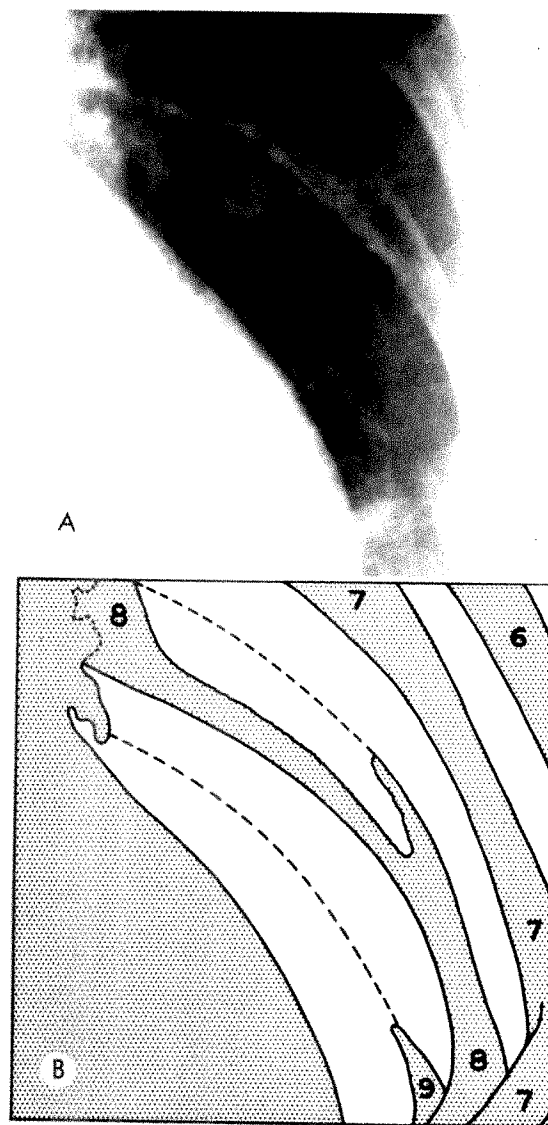


FIG. 4. (A) Marked erosion of left eighth and complete resorption of part of left ninth rib. (B) Diagram of A.

of time. Nevertheless, the finding may, when seen in a patient in whom hyperparathyroidism is not suspected, direct attention toward this possibility and indicate further studies.

SUMMARY

Subperiosteal resorption along the upper cortical margins of the ribs posteriorly has

been observed in patients with parathyroid adenomas and bone changes characteristic of hyperparathyroidism.

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COMPLETE CONGENITAL FISSURE OF THE STERNUM*

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A RARE isolated developmental anomaly of the sternum was recently observed on a routine hospital admission. This anomaly has been described in association with other abnormalities of the chest or abdomen, such as ectopia cordis.

REPORT OF CASE

F.R., a forty-six year old female waitress, was admitted to St. Michael Hospital with a lower abdominal mass, noted by the patient for a period of six months. There was no abnormality in the menstrual history. A panhysterectomy was performed with the pathologic diagnosis of leiomyomata uteri. During the routine hospital admission, attention was directed to a deep midline fissure in the anterior chest. Laminagrams of the sternum clearly demonstrated this unusual anomaly. No other skeletal developmental anomalies were discovered in the course of examination.

DISCUSSION

The sternum does not, as previously thought, originate from the ventral arches of the ribs, but develops from a single median rudiment which also gives rise to the shoulder girdle. According to Caffey,¹ the first sternal ossification centers appear in the manubrium during the sixth fetal month. Three paired centers of ossification then occur in succession in the body of the sternum. The manubrial ossification centers have fused at the time of birth, while fusion of the centers in the body is usually completed by the sixth year. Since the number of centers and the pattern of appearance and fusion show considerable variation, the sternum is an unreliable index of skeletal maturation.

Elias² described a complete sternal fissure in an asymptomatic woman, and more recently, Magan³ observed a similar anomaly



FIG. 1. Laminagram of the fissured sternum demonstrates the paired divisions of the manubrium, gladiolus and xyphoid.

with a vertical fold of skin extending from the symphysis menti to the sternum. A more common sternal anomaly is the foramen which is related to a vascular bundle, traversing the cartilaginous analogue during the fetal period.

Figure 1 shows the manubrium, gladiolus and xyphoid of the sternum to exist as three paired segments separated by a wide deep cleft. The paired xyphoid segments closely approximate each other at the caudal end. The second costal cartilage articulated in its normal position with the

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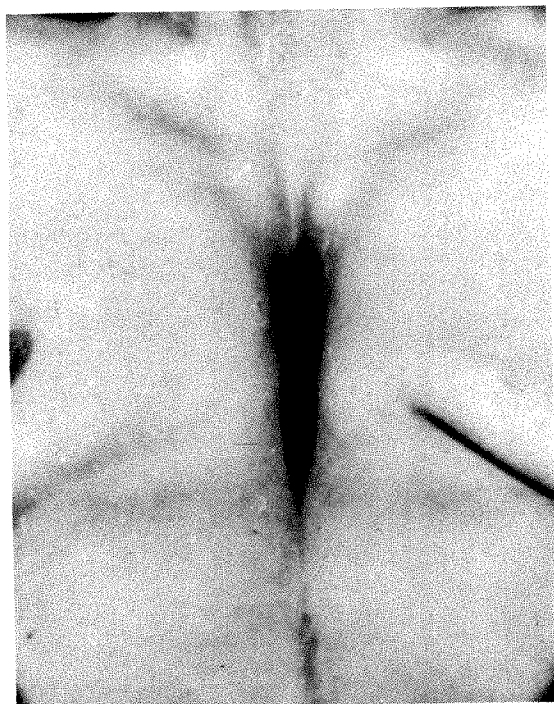


FIG. 2. Photograph shows the deep cleft between the sternal segments and a fibrous band extending to the umbilicus.

manubrial divisions. In this case, it appears that a developmental derangement oc-

curred as early as the sixth week of fetal life, preventing the sternal bands from fusing. In Figure 2 a prominent fibrous band extending from the xyphoid process to the umbilicus and a deep midline fissure, permitting one to palpate the heart and great vessels, are seen.

SUMMARY

A case of complete congenital fissure of the sternum is reported with a review of pertinent embryologic and roentgenologic aspects.

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ISOLATED FRACTURE OF THE ANTERIOR TIBIAL TUBERCLE

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FRACTURES of the tibia and fibula involving the ankle joint have been well described and classified.^{1,2,5} However, a search of the radiologic literature has not revealed a description of an unusual fracture of the ankle—an isolated fracture of the anterior tubercle of the tibia.

This fracture occurs with sufficient frequency to warrant some consideration. At the Bryn Mawr Hospital, a 350 bed community hospital, we have seen six such fractures in the three year period 1958–1961. During the course of the roentgen examination of the ankle in the presence of an isolated fracture of the anterior tibial tubercle, the fracture may be confused with fracture of the posterior tubercle of the tibia, an anomalous epiphyseal fissure, or even overlooked entirely.

ANATOMY AND MECHANISM OF INJURY

The anterior tubercle of the tibia forms the anterolateral margin of the distal extremity of the tibia. The external border of the tibia divides distally to form the anterior and posterior tubercles, and the groove between them accommodates the articulation of the distal fibula. The fibula is tightly bound into this articulation by the anterior and posterior, inferior tibiofibular ligaments.

The fragment resulting from an isolated fracture of the anterior tubercle of the tibia is known in the French literature as the "third fragment of Tillaux."³ Tillaux, a 19th century anatomist, attempted in cadaveric experiments to correlate the mechanism of ankle injury with the type of fracture produced.⁴ He found that abduction of the ankle often caused an isolated avulsion of the lateral margin of the distal tibia, but his illustrations showed in the anterior view avulsion of the anterior tubercle, and in the lateral view avulsion of

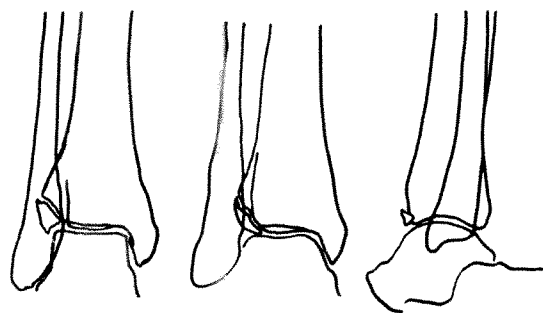


FIG. 1. Tracings of anteroposterior, oblique, and lateral roentgenograms of a case of isolated fracture of the anterior tibial tubercle. The more mesial portion of the fibular groove, the posterior malleolus, is intact.

the posterior tubercle.² Thus, he confused two different fractures. That the most lateral aspect of the distal tibia represents the anterior tubercle may be proved to one's satisfaction by examining the skeleton (Fig. 1). Ashhurst and Bromer² demonstrated the more mesial location of the posterior tubercle in roentgen studies of the fibular groove.

The mechanism of injury in the production of an isolated fracture of the anterior tibial tubercle is abduction of the ankle with external rotation of the foot putting stress on the anterior, inferior tibiofibular ligament sufficient to avulse a fragment from the anterolateral shaft of the tibia.

ROENTGEN FEATURES

This fracture is manifest roentgenographically in the anteroposterior projection (Fig. 2A; and 3A) by an oblique line of radiolucency passing downward and mesial to the lateral tibial margin into the articular surface. It is frequently obscured by the underlying fibula in this projection. The mesial portion of the fibular groove (the posterior tubercle) is seen to be intact. The lateral projection shows no abnormality in most cases (Fig. 2B), although occasionally

THE "RADIAL SUBLUXATION—FINGERNAIL DEFECT—ABSENT PATELLA" SYNDROME*

OBSERVATIONS ON ITS NATURE

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IN NEWLY recognized hereditary syndromes it is common to find that various components have already been described under other names, and that coincidental abnormalities have been included. This is impossible to avoid in the earlier reports and appears to be the case in the familial syndrome with anonychia of the fingers, absence of patellae, radial subluxations, and iliac "horns."

Usually cosmetic defects of fingernails give rise to the only complaints and patients are often unaware of many skeletal anomalies. There is a remarkable absence of disability, despite considerable alterations in the configuration of knee and elbow joints in many cases. While the genetic basis for the condition is controversial, it has been proposed that a single gene can be responsible for the different anomalies, especially the spectacular fingernail and patellar defects.¹¹

However, many other bony abnormalities are consistently associated with this condition and we wish to show that the entire skeletal system is abnormal. It is our purpose to point out the need for skeletal surveys when any single component of the syndrome is discovered, to try and throw light on this condition as a whole, and to demonstrate that the defects are not simple nor localized, as often supposed.

REPORT OF CASES

The opportunity to examine family B, none of whom had any complaints referable to joint abnormality, arose from a peculiar minor circumstance. Although the parents were aware that two of their five

boys had some abnormalities of the elbows and minimal deformity of the nails, they were not disturbed until they saw similar but more severe failure of fingernail development in their four year old daughter. They sought advice for this cosmetic defect only. It was realized from looking at the father's fingernails and arms (Fig. 1, 2 and 3) that this was an instance of hereditary anonychia-radial subluxation type. The parents generously cooperated in having the rest of their family examined.

CASE 1. The father, now aged forty-four years, is an energetic, alert Englishman, and was an excellent rugby player at the time of examination. He was occasionally irritated by his "split nails" (Fig. 1) catching on his clothing and had been aware since childhood of some unchanging limitation of all movements in his elbows, and of inability to extend his wrists or to make a tight clenched fist. He was quite used to this and had served in the army for a con-



FIG. 1. Case 1. The middle fingernail on each hand is intact. Other nails have central splits or clefts of complete nail aplasia (arrow). The thumb nails are most severely affected.

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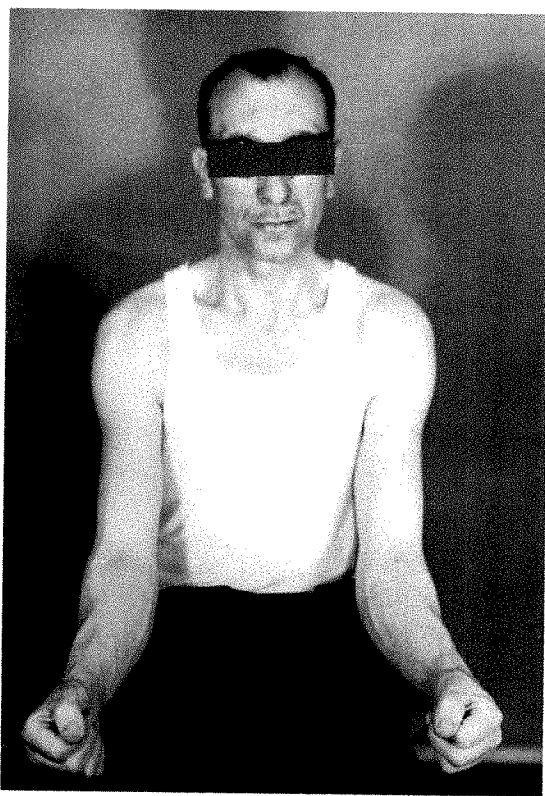


FIG. 2. Case 1. The arms are shown in the full extent of supination and extension with the fists clenched to their limit. Note the atrophic thumb nails.

siderable period as an instructor but was finally released when it was noted that he could not hold a rifle on parade "at the present," since it required full supination of the hand (Fig. 2). He continued extensive athletic activity after his discharge and, apart from a transient bout of glomerulonephritis in 1941, has been completely healthy.

On physical examination he showed a 30° limitation of supination and pronation of the forearms, with a 20° limitation of full extension and a 10° limitation of full flexion of the elbow joints. Although his wrists flex fully, they cannot be extended beyond the axis of the forearm and there is subluxation of the radial heads (Fig. 3 and 4). His fingers show slight diminution in the range of all joint movements so that tight doubling of the fingers into the palms is not possible. He was completely unaware of his small symmetric and vertically based iliac "horns" or of his hypoplastic patellae, although some flattening of this region on flexion of the knees is evident. He has a full range of move-

ment in the shoulder joints but these show some roentgen abnormalities (Fig. 5).

CASE II. This fifteen year old son of CASE I is much smaller physically than his binocular twin brother (CASE III) and has more pronounced anomalies in all areas but no complaints. The degree of limitation of elbow movement is similar to that in the father. The complete absence of the patellae and roentgen abnormalities of the knees, elbows and ankle joints are shown in Figures 6, 7, and 8. He has posterior dislocation of the left radial head and lateral dislocation of the right on roentgenograms, but these structures can swing around the lateral condyle, altering the type of subluxation. Some sclerosis of the growing ends of the bones is present (Fig. 8) but there is no history of heavy metal ingestion and this finding could be coincidental and physiologic. The talus is infantile in shape on both sides. The anterior end of the left calcaneus has failed to develop

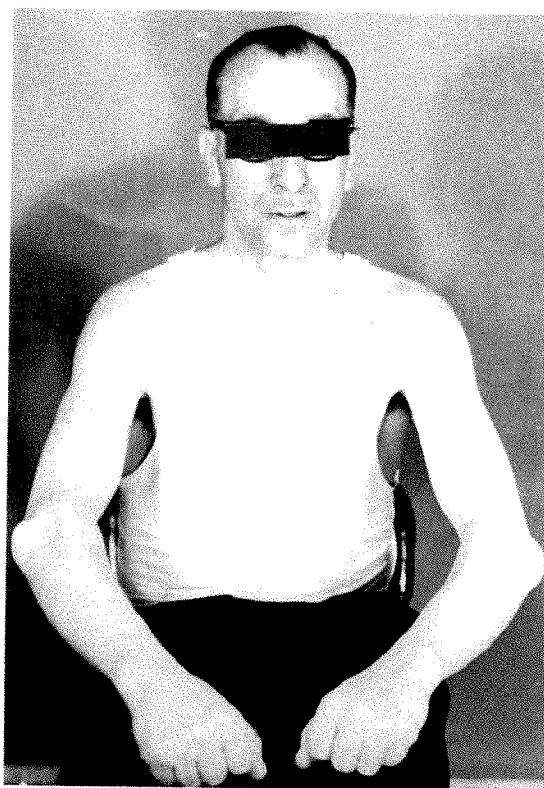


FIG. 3. Case 1. The arms are pronated and extended to their full extent. The wrists cannot extend beyond the forearm axis. Note the bulging subluxated radial heads.

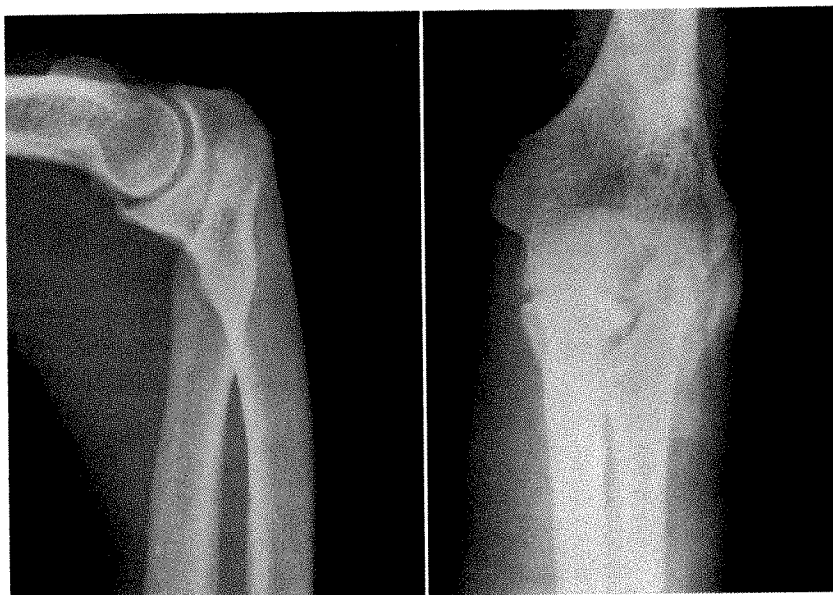


FIG. 4. Case I. Anteroposterior and lateral views of the left elbow joint. The radius is elongated, with a small head subluxated posteriorly. The olecranon is hypoplastic and the coronoid process shows a hook-like osteophyte. The medial epicondyle is prominent.

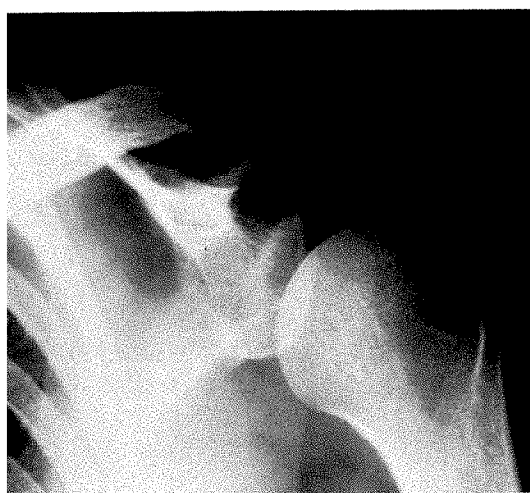


FIG. 5. Case I. Note the relatively small, shallow glenoid fossa in comparison with the humeral head. The remainder of the scapula appears to be normal.



FIG. 6. Case II. Lateral view of the knee. The patella is absent and there is delayed maturation for the chronologic age of fifteen years. The epiphyseal center for the tibial tubercle has not yet appeared.

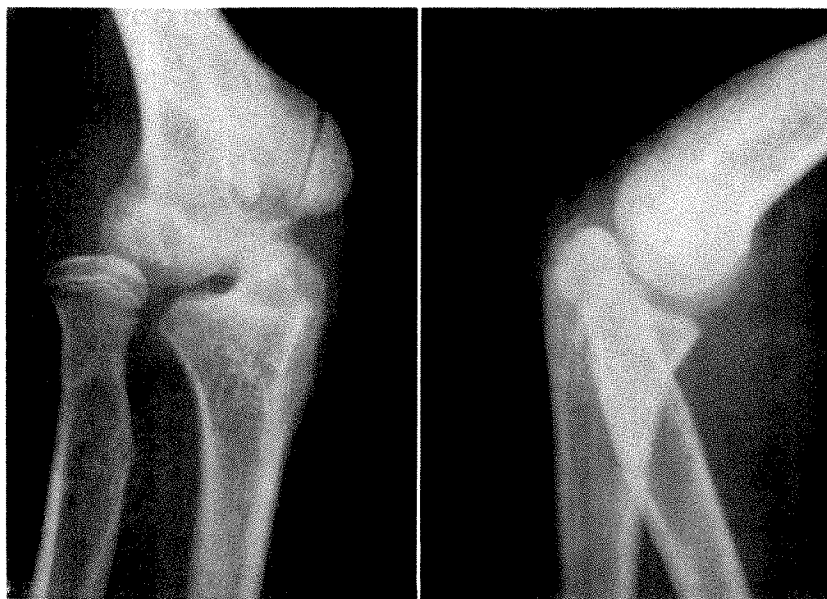


FIG. 7. Case II. Anteroposterior and lateral views of the right elbow showing an elongated radius. The abnormally rounded head is subluxated posteriorly and laterally. Hypoplasia of the olecranon is present and there is a prominent center for the medial epicondyle. The capitellum is enlarged contrasting with the hypoplastic trochlea.



FIG. 8. Case II. Lateral view of the left ankle showing shortening of the calcaneus, absence of the anterior tubercle and flattening of the adjacent articular

surfaces normally and is 1 cm. shorter than the right. Iliac "horns" are present (Fig. 9).

CASE III. This twin brother of CASE II is physically much larger. He shows hypoplastic patellae and less delay in maturation, for example of the tibial tuberosities (Fig. 10). The elbows and wrists are almost normal roentgenographically. He too has vertically based iliac "horns." Bilateral spondylolysis at L_5 is present in contrast to only the right sided occurrence in his twin. (This is thought to be a coincidental finding in both cases.) The ankle joints show no abnormalities.

CASE IV. The four year old daughter of CASE I shows almost complete absence of fingernail formation on all fingers and both thumbs. She has a degree of limitation of movement of the elbows, wrists and fingers similar to that seen in her father. No pelvic "horns" are as yet visible roentgenographically. Posterior subluxation of the right radial head is present (Fig. 11), but

surfaces of the talus and calcaneus. The talus shows no waist and the superior margin of its head and body are almost linear.

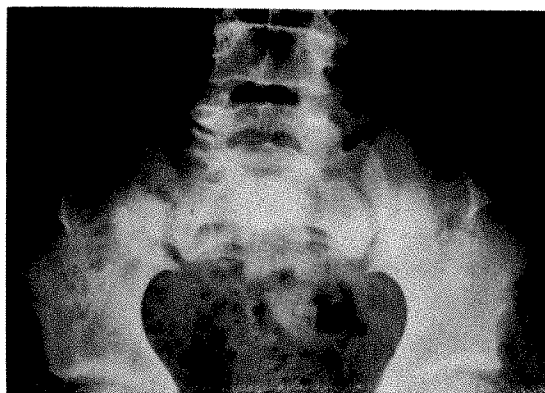


FIG. 9. Case II. Symmetric triangular spinous processes (iliac "horns") are present on the posterior surface of the iliac bones. Note the linear and vertical base pointing towards the acetabulum. Coincidental right spondylolysis of L₅ is evident.

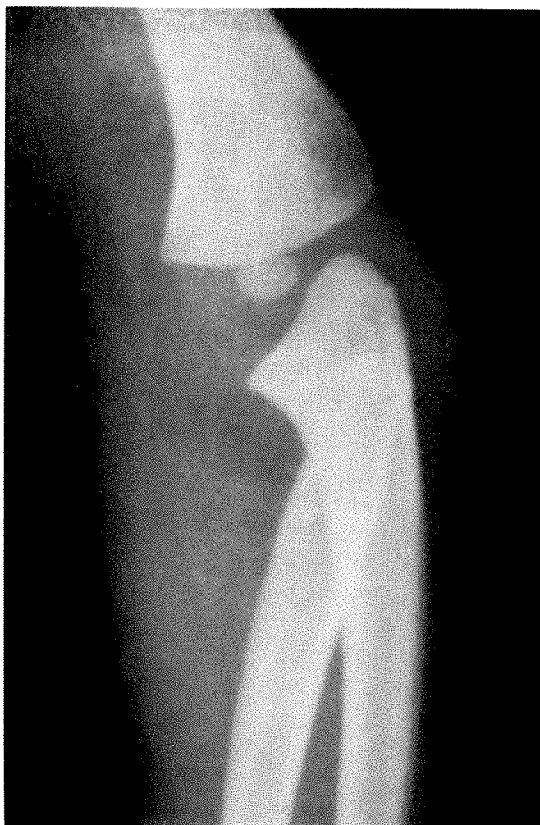


FIG. 11. Case IV. Lateral view of the right elbow of a four year old girl showing posterior subluxation of the radial head. The left elbow showed no abnormality roentgenographically.

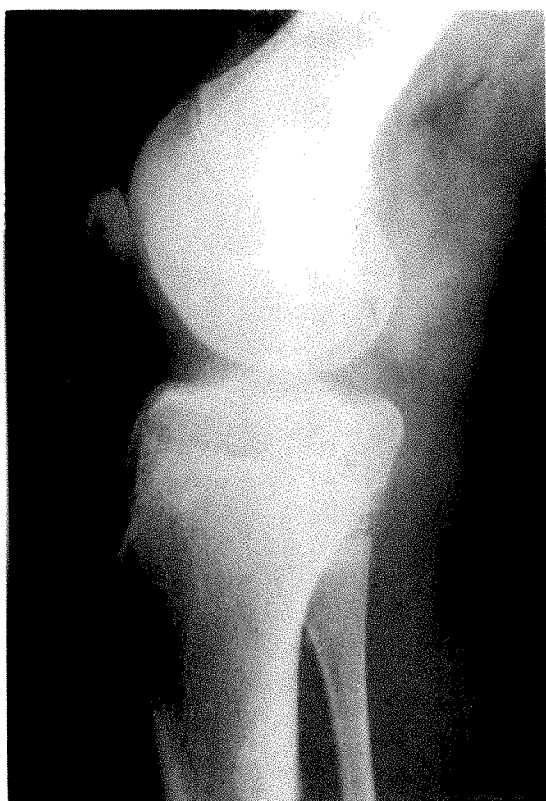


FIG. 10. Case III. Lateral view of the knee showing the hypoplastic patella. The center for the anterior tibial tuberosity is present but is not united. A coincidental enostosis is present in the posterior tibial shaft.

the left elbow joint is normal. The patellae, usually not roentgenographically evident at this age, were not clinically palpable.

The two eldest sons and a twelve year old son of CASE I are free from anomalies. There is no knowledge of any of these anomalies in the grandparents or great grandparents, all of whom have been notably long lived. No incidence of illness resembling glomerulonephritis is known in any member of the family except the father and none showed abnormal urinalyses.

DISCUSSION

The father (CASE I) was given a medical discharge from the army on the basis of the roentgen demonstration of subluxation of the heads of the radii. Patellar, wrist and hand defects were not detected at this

time and, except by chance, the familial and more extensive nature of the condition would have remained undiscovered. It is worthy of note that this has been the typical experience when components of the syndrome have been considered as isolated findings. For example, in a careful report by Fox and Griffin³ on hereditary dislocation of the radial head, they note, as minor findings, the presence of hypoplastic patellae, some nail dyscrasias and mild deformities of the fingers. Even the first intimation in the literature of the existence of this syndrome occurs quite incidentally in a report by Little (1897),⁸ which is concerned primarily with a review of the congenital absence or delayed development of the patella. He mentions in passing an affected family which also showed failure of development of the thumbnails.

With the availability of roentgenographic surveys, the main features of this syndrome began to be grouped under descriptive names, especially by some German authors,¹² which make them easy to trace in the literature. Latterly they have been reported under a most confusing array of synonyms, for example, familial dyschondroplasia,⁷ hereditary arthrodysplasia,¹⁴ iliac horns,^{2,4} arthro-onychodysplasia,¹ Turner's syndrome,¹⁵ osteo-onychodysplasia,⁹ congenital dislocation of radial head,³ and hereditary onycho-mesodysplasia.¹⁰ An example of the confusion arising from this multiplicity of terms is Turner's¹⁵ belief that he was describing in 1933 an unrecorded syndrome.

In the family studied by us we have been struck by the asymmetric development of joints, with hypertrophy on one side and hypoplasia on the other and the reciprocal alteration in the length of paired bones, in addition to the more spectacular changes noted in most articles. These asymmetries are features of roentgenograms illustrating many reports but the emphasis is largely upon the hypoplasia. This oversimplification obscures the extent and nature of the syndrome. The lack of a proportional relationship is seen in all the skeletal areas we

surveyed. For example, in the arm the head of the humerus, the capitellum and the radius are all enlarged or elongated; the glenoid cavity, trochlea, olecranon and ulna are small. In the knee the medial condyles of the femur are often disproportionately large,¹⁵ and the lateral condyles hypoplastic.¹⁰ The patella is probably defective as an axial structure and possibly should not be regarded as a sesamoid bone in any case. Certainly no sesamoid bones elsewhere are affected.

Surprisingly, the toenails are normal in these cases and can be used as transplants in plastic surgery to minimize the cosmetic abnormalities of the fingernails which are so often seen. The statement is often copied from report to report that the incidence of nail hypoplasia decreases from the thumb to the little finger. However, where illustrated the hands often show the second fingernail to be fully formed, with axial clefts of complete nail aplasia in the flanking fingers.¹⁷ In the thumbnail abnormalities, some emphasis has been placed upon the relatively marked hypoplasia of the radial halves. This fingernail segmentation and middle finger sparing is reminiscent of the abnormalities seen in hereditary axial, preaxial and postaxial anomalies of the fingers.¹³

The discovery of bilateral symmetric iliac "horns" is of relatively recent date. They were first described by Keiser⁶ (1939) but can be seen very clearly in roentgenograms reproduced in Turner's¹⁵ excellent report of 1933, which was apparently the first to raise a suspicion that this syndrome is a general skeletal disorder. It is not clear from the text whether or not he regards the "horns" as an abnormal curving of the external surface of the iliac wings. Since then, they have been recognized frequently. Jameson *et al.*⁵ noted their presence in 30 per cent of affected families. No explanation of their nature has appeared in the literature to the best of our knowledge. Hawkins and Smith⁴ point out that they have not been seen in the pelvis of any mammal, and they are too laterally placed

for us to suspect that they represent sacral ribs. In a careful study of our own cases and of the published roentgenograms we noted that they are spines, rather than circularly based horns, vertically oriented and in line with the acetabulum. Hawkins and Smith⁴ show a cap-like epiphysis in those appearing in a fourteen year old girl. From their situation, the nature of the formation and their markedly spinous character, so well-illustrated by McCluskey,¹⁰ we suspect very strongly that they are developments analogous to the scapular spinous process. As McCluskey¹⁰ and others have noted, the scapulae tend to be small with long acromion processes. If we assume the overdevelopment of a potentiality to form a spine on the iliac wing, pointing towards the joint, this would accord with the observed over- and underdevelopment of many other contiguous osseous structures throughout the body.

No visceral abnormalities have been confirmed as components of this syndrome. Hawkins and Smith⁴ reported a very suspicious concurrence of glomerulonephritis in an affected family. However, this showed no histologic peculiarities and has not been referred to in subsequent reports. A considerable number of other changes has been recorded as part of the syndrome in non-radiologic journals—for example, calcification of the falx and hyperostosis frontalis interna, both of which are probably of physiologic nature. Similar sporadic reports of concurrent spina bifida, supernumerary digits and thoracic kyphosis have appeared intermittently. It seems likely that most of these conditions are not part of the syndrome itself. Similarly, although fingernails are strikingly affected, other ectodermal structures such as toenails, teeth, hair and skin have shown no comparative abnormalities.

SUMMARY

Observations are reported on members of a family who showed the "radial subluxation—fingernail defect—absent patella" syndrome. Disproportionate development

of axial, preaxial and postaxial structures probably produces these local features. Attention is drawn to other anomalies which either have not been described or have not been previously correlated with this syndrome—notably, asymmetric development of joints, hypoplastic glenoid formation and iliac "horns" which have been explained as probable analogues of scapular spines.

There is a characteristic lack of disability in our cases. It is evident that this hereditary condition is a generalized abnormality of endochondral skeletal growth.

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PAROSTEAL LIPOMA*

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MANY individual cases of parosteal lipomas have been published in the past forty years, but the data have not been adequately analyzed. It is the purpose of this paper to tabulate and evaluate the reports that have appeared in the literature (Table I) and to present the history of 2 patients whom we have observed. The publications prior to 1918 were not reviewed since this had been done so ably by Bohm.⁴ To date, over 100 cases have been documented in the world literature.

This subject has received little attention in the radiologic journals. Moreover, the standard reference works by such outstanding authorities as Pack and Ariel³⁰ Jaffe,¹⁸ and Stout³⁸ offer little information on this problem. One of these authors writes: "Even when a lipoma evolves in proximity to a bone (in a limb, for example) and even if it grows to fairly large size, the fact that the tumor has no infiltrative qualities and that it is also soft and yielding precludes its affecting neighboring bone."¹⁸ However, on the basis of the literature and our experience, there may, indeed, be bony changes associated with a parosteal lipoma (Tables II and III).

The lipoma is the most common tumor of the body. It can be found in virtually every tissue or organ, but it most often originates in the subcutaneous tissue of the neck and back. Less frequently, it is observed in the muscles of the extremities. The two lipomas which will be discussed in this paper arose in the soft tissue adjacent to bone.

A parosteal lipoma is a benign fatty neoplasm having an intimate relationship to the periosteum. Although the term "periosteal lipoma" has been used by most authors in the past, we feel the term "parosteal lipoma" (as introduced by Power³³)

is more suitable since it indicates contiguity with bone rather than implying a definite origin from the periosteum. The incidence of the tumor is 0.3 per cent of all lipomas.¹⁶

The original description of this entity was published in the German literature by Seerig³⁵ in 1836. The subject was introduced to the English literature by Smith³⁶ in 1866. A comprehensive investigation by Schwartz and Chevrier³⁴ appeared in 1906, at which time they analyzed the 55 cases presented in the literature up to that date. In 1918,⁴ Bohm reviewed the articles reported in the twelve year interim and contributed an excellent critique of the problem.

PATHOLOGY

A lipoma may be defined as a neoplastic aggregation of fat cells which are morphologically and histochemically identical with the lipocytes of subcutaneous tissue. It has been shown, however, that the rate of lipid synthesis in the lipoma is greater than in the normal adipose tissue of the same subject.¹⁴ A fibrous capsule circumscribes the fatty mass. The mature lipocyte is incapable of mitosis, but the sparse lipoblasts scattered along the connective tissue septa and along the blood vessels serve as foci for neoplastic proliferation. Grossly, the lipoma presents as a soft, lobulated, encapsulated mass of uniform consistency and texture with a greasy yellow appearance on cut section. The fat cell is thin-walled with a flattened eccentric nucleus, the cytoplasmic contents having been removed by solvents employed in the histologic preparation.

The parosteal lipoma is basically identical with the conventional subcutaneous lipoma. Its osseous relationship is the deciding factor in nomenclature. The union

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TABLE I
TABULATION OF CASES FROM THE LITERATURE

Year of Publication	Author	Age of Patient When First Examined (yr.)	Sex	Bone Involved	Duration of Symptoms (yr.)	Chief Complaint	Preoperative Diagnosis	Roentgen Findings	Attachment to Bone at Surgery	Recurrence
1919	Gery and Petit-Dutailhig ¹³			Scapula		Mass in back of head			Firm	
1920	Pelissier ²¹	50	M	Occiput	4 1/2	Mass in back of head				
1920	Treves ⁴⁰	5 1/2	F	Ulna	4	Enlarging mass in forearm	Parosteal lipoma	Normal bones	Loose	No
1924	Stammeler ²⁷	3 1/2	M	Rib	3 1/2	Apple-sized tumor in back	Lipoma	Osteomyelitis and lipoma were the considerations	Firm	Yes
1928	Jorgensen ²⁰	5 1/2	M	Metacarpals	7-8	Lump in dorsum of hand		4-5 cm. radiolucency between 1st and 2nd metacarpals with narrowing of shaft of 2nd metacarpal	None	
1928	Laurell ²²	60	M	Femur	20	Gradually increasing mass in thigh		Oval radiolucent image with an osseous projection arising from femur extending into the radiolucency	Firm	
1930	Bartlett ¹²	7	M	Humerus	5	Tumor of arm	Ganglion, Bursa	Encapsulated radiolucency with fan-like radiating markings	Firm	No
1930	Bartlett ¹²	6	M	Tibia	3	Gradual enlargement of leg, with rapid enlargement recently	Fibrolipoma	Encapsulated radiolucency causing great anterior bowing of tibia	Firm	No
1930	Chasin ⁷	25	F	Radius	1 1/2	Painless swelling	Fibroma, Angioma, Lipoma	Sharply defined area having a similar density as the subcutaneous fat	Firm	
1930	Chasin ⁷	45	F	Tibia	8	Swelling with rapid increase in size in past year	Fibrosarcoma	Image similar to subcutaneous fat with smooth contour	Loose	
1930	Chasin ⁷	40	M	Tibia	3	Mass	Lipoma			
1930	Chasin ⁷	60	M	Femur	20	Mass	Lipoma	8.5 by 15 cm. oval radiolucent image with osseous projection extending into tumor		
1930	Porzelt ²⁸	16	M	Metatarsal	1 1/2	Swelling in foot	Lipoma	Interspace between 4th and 5th metatarsal markedly widened forming a pincer about tumor	None	
1934	Canger ⁶	54	F	Tibia	13	Mass		Oval radiolucency penetrated by an exostosis arising from radius	Loose	
1934	Vernengo ⁴³	30	F	Radius	4	Painless mass		Soft tissue radiolucency with roughening and thickening of bone	Firm	
1935	Dujovich and Schrauent ¹¹		F	Femur	1 1/2	Painless mass	Sarcoma		Firm and Loose	
1939	Moulouguet <i>et al.</i> ²⁵	60	M	Femur		Tumor above knee	Osteosarcoma	"The osteoma is situated in the vastus internus with irregular and ill-defined contours"	Firm	

TABLE I (Continued)

Year of Publication	Author	Age of Patient When First Examined (yr.)	Sex	Bone Involved	Duration of Symptoms (yr.)	Chief Complaint	Preoperative Diagnosis	Roentgen Findings	Attachment to Bone at Surgery	Recurrence
1940	Mackenzie ²⁸	60	F	Radius	4	Painless mass	Lipoma	Soft tissue radiolucency	Firm	
1941	Janket ¹⁹	59	F	Femur	2	Mass	Lipoma	8 by 20 cm. radiolucency containing linear densities and associated with an exostosis	Firm	
1941	Velasco ⁴¹	15	F	Fibula	8	Painless mass		Radiolucency in contact with bone	Firm	
1943	Cottini ³	19	F	Humerus	15	Mass		Radiolucent image		No. Returned with radial nerve paralysis
1944	Velasco ⁴²	84	F	Femur	20	Painless swelling		Well-delineated radiolucency with roughening of adjacent bone and exostosis	Loose and Firm	
1946	Ayerza and Varalla ¹	49	M	Femur	4½	Painful mass (following injury)		Radiolucency	Firm	
1946	Moulouquet ²⁸	65	F	Femur	Several	Painless mass with rapid increase in size recently				
1946	Moulouquet ²⁸	43	F	Radius and Ulna	15	Painless mass		Radiolucency in soft tissues with speckled areas of calcification in the radiolucency		No. Returned with radial nerve paralysis
1946	Moulouquet ²⁸	65	F	Humerus	15	Mass		Radiolucent image		
1954	Hummel and Truong-Thi-Danh ¹⁷	68	F	Femur	Many	Mass with recent spurt in growth		Oval transparent image accompanied by a periosteal reaction	Loose and Firm	
1957	Ferrari ¹³	67	M	Humerus	1½			Triangular bony mass with apex directed toward 8 by 12 cm. radiolucency	Firm	
1959	Kenin <i>et al.</i> ²¹	4	F	Fibula and Tibia		Swelling of left calf		11.5 by 5 cm. radiolucency with anterior bowing of tibia, irregularity of fibula. Sclerosis of cortices	Firm	None. Residual bowing but sclerosis disappeared
1959	Kenin <i>et al.</i> ²¹	49	M	Femur		Mass in left thigh		Radiolucent mass over anterior thigh. Several bony excrescences projected from femur into radiolucency	Firm	None
1960	Fleming <i>et al.</i>	52	F	Femur	1½	Painless swelling	Liposarcoma	Large area of radiolucency with an osseous projection at the mid-portion of lucency	Firm	None after 3 years
1960	Fleming <i>et al.</i>	53	M	Radius	15	Lump	Lipoma or Liposarcoma	Bilobed radiolucency in soft tissues of forearm associated with cortical thinning of radius	Loose	None after 10 months

TABLE II
FREQUENCY OF BONE INVOLVEMENT IN
FOUR DIFFERENT SERIES

Bones Involved	Fleming	Dujovich and Shraer ¹⁰	Schwartz and Chevrier ³⁴	Bohm ⁴
	(per cent)	(per cent)	(per cent)	(per cent)
Femur	34	18	15	15
Radius	18	3	3	1
Tibia	14	4		2
Humerus	9	7	3	1
Fibula	5			
Ulna	5	3		3
Metacarpal	3	1	3	3
Rib	3	5		3
Skull	3	30	48	36
Scapula	3	4	3	3
Metatarsal	3	3	2	3
Vertebral column		12	15	18
Clavicle		5	3	5
Pelvis		5	5	7

of the lipoma with adjacent bone may be loose or firm.

The changes in the bone at the site of attachment are variable. In the 32 cases reviewed in this paper, approximately one-third showed no bony changes. However, in 11 cases an overproduction of cortical bone and in 5 cases osseous bowing or cortical erosion could be identified. Where these osseous alterations are present, the attachment of the lipoma to the bone is likely to be very strong, although an intimate union can occur without any bony change.

The only report of the microscopic anatomy of the junction zone of the lipoma and hyperostosis is by Moulouquet *et al.*²⁷ In their patient a hyperostosis projected into the lipoma. They believed that the femoral periosteum not only completely surrounded the lipoma but also continued between the lipoma and osseous projection. We wonder, however, if these authors are confusing the fibrous capsule of the lipoma with the periosteum.

Dr. C. Zent Garber studied the junction zone of bone and lipoma in our first patient, E.S. Three different histologic patterns

were observed. In some sections the osteogenic periosteum was thick and cellular, and no fibrous periosteum was present between it and the lipoma. In other places the osteogenic and fibrous layers of the periosteum were very thin. There were also areas where there was no intervening periosteum, the lipoma being in direct contact with the hyperostosis. This excrescence was composed of immature subperiosteal new bone.

ETIOLOGY AND PATHOGENESIS

The etiology and pathogenesis of these tumors remain obscure although various theories have been proposed. A congenital origin and trauma have been suggested as etiologic factors, but there is little evidence to support either. Schwartz and Chevrier³⁴ postulated inflammation as the cause, suggesting that a localized periostitis stimulated a lipomatous transformation of the local bone. Bohm⁴ believed that these tumors did not actually originate from the

TABLE III
TYPE OF BONE CHANGES

Authors	Bone	Osseous Changes
Barlett ³	Tibia	Bowing
Chasin ⁷	Femur	Osseous projection
Case 2		
Dujovich and Shraer ^{10,11}	Femur	Roughening and thickening of the cortex
Ferrari ¹³	Humerus	Osseous projection
Fleming		
Case 1	Femur	Osseous projection
Case 2	Radius	Erosion
Hummel and Truong-Thi-Danh ¹⁷	Femur	Subperiosteal new bone formation
Janker ¹⁹	Femur	Osseous projection
Jorgensen ²⁰	Metacarpal	Erosion
Kenin <i>et al.</i> ²¹		
Case 1	Tibia and Fibula	Bowing and sclerosis
Case 2	Femur	Osseous projection
Laurell ²³	Femur	Osseous projection
Moulouquet <i>et al.</i> ²⁷	Femur	Osseous projection
Porzelt ³²	Metacarpal	Bowing
Velasco ⁴²	Femur	Osseous projection
Vernengo ⁴³	Radius	Osseous projection

periosteum, but merely grew into this structure during their development.

From our microscopic findings it seems reasonable to assume that the osseous projection is stimulated by the lipoma, although the mechanism is unknown. The site of origin of the parosteal lipoma, whether within the periosteum or outside of this structure, cannot be determined. The fact that periosteum contains no fat cells is one argument in favor of the extraperiosteal origin of these tumors; yet, lipomas are found in certain organs (kidney, uterus) that normally do not have fat cells. The often quoted "cell rest theory" might be invoked as an explanation for the ectopic location of these lipomas.

CLINICAL FEATURES

The clinical features of these lesions follow the pattern of subcutaneous lipomas with the exception of location and number. Whereas subcutaneous lipomas are commonly found in the neck, shoulders and back and may be multiple, the parosteal lipoma is almost exclusively in the extremities and is always solitary. In a typical case, the patient will describe a mass which has been present for an average of eight to ten years, although there are patients in whom the mass was allegedly present for as short as three weeks or as long as forty-one years prior to seeking medical advice. Pain was described in one case.² Disturbances in motor and sensory function of adjacent nerves may occur due to local pressure. In the series of 32 patients studied, over one-half of the patients were in the forty to seventy age group, the youngest being three months and the oldest eight-four years of age. There were 14 males and 16 females. In 2 patients the age and sex were not recorded.

The most frequent site of the parosteal lipoma was the thigh, the femur being involved in 11 cases. The tumor was found in the upper extremity in 11 cases and in the lower extremity in 18 cases. The extremities thereby accounted for all but 3 cases. This is in contrast with the earlier literature,

where it is stated that this tumor commonly arose adjacent to the skull.

On physical examination the presence of a mass was the cardinal feature. The size varied but usually was large. There was no associated tenderness, and the consistency of the mass was often difficult to evaluate because of the bulk of the overlying muscle, especially in the thigh.

A parosteal lipoma cannot be diagnosed on clinical examination alone. Laboratory tests are normal. However, with the aid of roentgenograms this lesion may be diagnosed preoperatively.

ROENTGEN FEATURES

In 1915, Koehler²² first described the typical roentgen appearance of the lipoma by noting the radiolucency of fat in contrast to the surrounding muscle. Ten years later, Bufalini³ independently arrived at the same conclusion. By recognizing the association of the soft tissue radiolucency with the bony alteration, Bartlett³ was one of the first to make a correct preoperative diagnosis.

The absorption of roentgen rays by body tissue depends on its density, the average atomic number and the wave length of the radiation. The absorption of roentgen-ray photons in the diagnostic range of energies varies directly with the fourth power of the atomic number.

<i>Tissue</i>	<i>Effective Atomic Number*</i>
Fat	5.9
Water	7.4
Muscle	7.4
Bone	13.8

It is also known that the differential absorption of fat and muscle will increase as the wave length becomes longer; *i.e.*, by decreasing the kilovoltage. Consequently, the best definition of fatty tissue will be obtained when low voltage is used (30 to 40 kv.), and when the fat is surrounded by enough contrasting tissue of muscle density.

* Hine, G. J., and Brownell, G. L. *Radiation Dosimetry*. Academic Press Inc., New York, 1956, 16, 90.



FIG. 1. Case 1. Female, fifty-two years old. History of a painless swelling for a period of seven months. Roentgenogram shows a well-defined radiolucent mass adjacent to the femur, with an associated bony excrescence.

From the chemical standpoint the fat content of lipomas is equal to that of normal fat and, consequently, these tumors usually absorb roentgen rays to the same extent as normal subcutaneous fat. Chasin⁷ found that a lipoma in the arm must be at least 2 cm. in diameter to be roentgenographically demonstrable, and 1.5 cm. in the forearm. In the thigh, the mass must be 10 cm. and in the lower leg 6 cm.

The usual roentgenographic appearance of a parosteal lipoma is a well-defined area of radiolucency lying in close proximity to bone, commonly a long bone. Fine linear radiodensities, representing the fibrous connective tissue septa, as well as calcification and even ossification, may be seen within the radiolucent mass. The bone may appear normal. However, 16 out of the 27

cases in which the roentgenographic findings were recorded had definite bony alterations. A hyperostotic reaction was evident in 11 cases. Bowing of the adjacent bone away from the tumor was present in 3 patients, all of whom were in their first or second decade of life. No hyperostotic change or cortical thinning has been described in this younger age group. Cortical erosion was seen in 2 adults, however.

REPORT OF CASES

CASE 1 (Fig. 1, 2 and 3). E.S., a fifty-two year old white female, was admitted to the Columbia-Presbyterian Medical Center on February 21, 1958, with the chief complaint of a tumor of the right thigh. The patient had noted a painless swelling superior and medial to the right patella for the past seven months. She noted no appreciable change in its size in the interim. Approximately seven weeks prior to admission she experienced pain on the medial aspect of the right knee associated with instability on ambulation. The pertinent physical findings were limited to the right lower extremity, where a firm, nontender, 6 by 15 cm. oval mass was palpated on the anteromedial aspect of the thigh, with the lower border roughly 10 cm. proximal to the knee joint. There was no inguinal lymphadenopathy. The clinical impression was a soft tissue sarcoma. The hemoglobin was 11.8 gm. The erythrocyte sedimentation rate (Westergren) was 31 mm. per hour. A roentgenogram of the right femur was obtained and revealed a well-defined radiolucent mass measuring $15 \times 7 \times 5$ cm. situated adjacent to the medial aspect of the distal femur. An additional finding was the presence of a 5 cm. osseous projection arising from the medial aspect of the femur. The bony excrescence was situated in the mid-portion of the fatty mass previously described. The roentgenologic impression was lipoma or liposarcoma. A skeletal survey and chest roentgenogram were normal. On February 25, the patient was taken to the operating room. Beneath the intermedial, which was thinned out and compressed, was a benign appearing fatty tumor, with the characteristic yellow appearance and fibrous capsule of a lipoma. It presented as a 9×17 cm. lobulated mass completely surrounding the medial aspect of the lower femur. The tumor was firmly adherent to a 2.5×7 cm. plateau of

cortical bone which presented on the antero-medial aspect of the femur. The tumor, which appeared grossly benign, was dissected free from the muscle, and the plateau of bone was removed by means of an osteotome. Permanent pathologic sections revealed a lipoma associated with considerable reactive new bone.

Comment. This patient presented the usual clinical, roentgenographic and surgical findings of parosteal lipoma. The knee pain was probably related to degenerative changes and had no relation to the tumor. Three years postoperatively the patient was asymptomatic with complete range of knee motion. Roentgenograms of the right thigh revealed no bone or soft tissue abnormalities.

CASE II (Fig. 4). L.C., a fifty-three year old Negro male, was admitted to the Columbia-

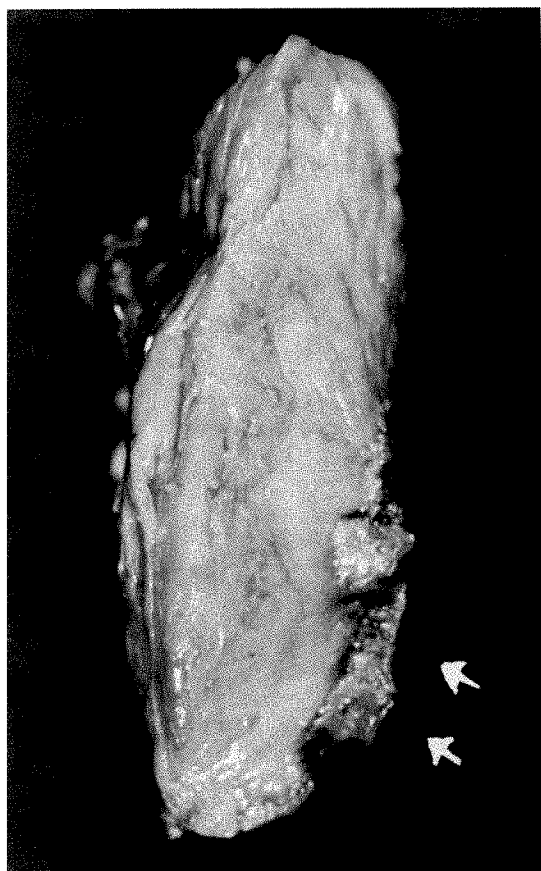


FIG. 2. Case I. Cut surface of surgical specimen demonstrating the parosteal lipoma attached to resected bony protuberance (arrows).



FIG. 3. Case I. Histologic section at junction zone of lipoma and bony excrescence. There is segmental thickening of the periosteum between the lipoma (above) and the immature cortical bone (below).

Presbyterian Medical Center on May 5, 1960, with a history of a "lump" in the right forearm which had been steadily increasing in size for fifteen years. The swelling had been completely painless and had caused no limitation of motion. Occasionally, the patient noted moderate "tightness" in the area while working with that arm. There was no history of trauma. On physical examination, there was a large, very firm, nontender, fixed mass that measured 9 cm. in the long axis. The remainder of the examination was unremarkable. Specifically, there were no motor or sensory deficits in the upper right extremity. The clinical impression was lipoma or liposarcoma. Laboratory studies were unremarkable. Roentgenograms of the right forearm demonstrated a large, oval, bilobed, radiolucency in the soft tissue of the proximal forearm. There was also a small area of cortical thinning of the radius adjacent to the mass. The ulna appeared intact. The preoperative roentgen diagnosis was lipoma or liposarcoma. The patient was taken to the operating room on

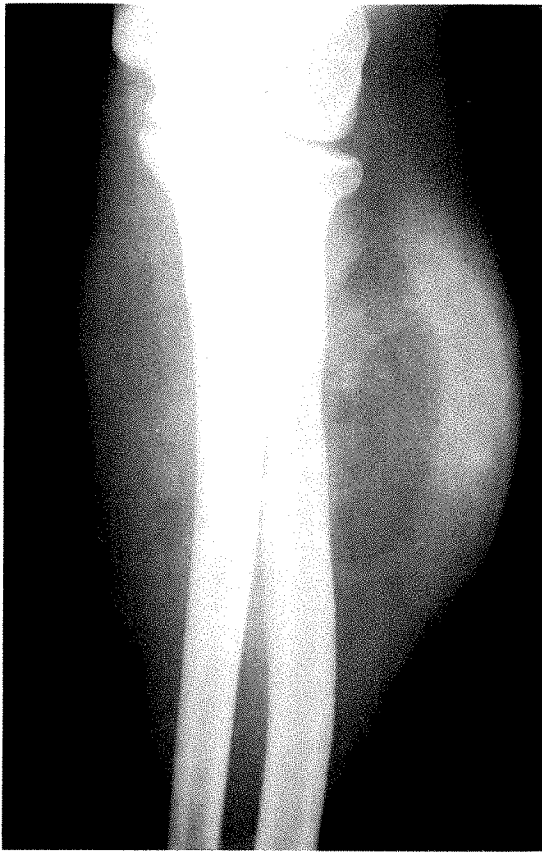


FIG. 4. Case 11. Male, fifty-three years old. History of "lump" for a period of fifteen years. Roentgenogram shows a bilobed radiolucency adjacent to the radius with pressure erosion of the cortex.

May 21 for an open biopsy. The pathologic report was lipoma. On May 27, a bilobed encapsulated tumor was found to be situated beneath the extensor carpi radialis longus and brevis, overlying the supinator. The deep component split the supinator and lay over the ulna lateral to the oblique line. On the lateral aspect of the mass was the dorsal interosseous branch of the radial nerve, which was identified and carefully preserved. The capsule was loosely connected to the radius. Postoperatively, the patient had a wrist drop and weakness of extension of the fingers and thumb, but this slowly improved.

Comment. This case presents again the typical history of a painless mass of many years' duration. The roentgenographic changes of a large radiolucency with erosion of the adjacent bone were certainly consistent with the diagnosis of a parosteal

lipoma, but a liposarcoma might give a similar appearance. The postoperative course was complicated by an interosseous nerve palsy. Follow-up examination approximately seven months after surgery revealed some residual weakness in the right hand. Roentgenograms of the right forearm at that time showed an area of new bone formation at the site of attachment of the lipoma.

DIFFERENTIAL DIAGNOSIS

There are many causes of localized swelling in an extremity and they include lesions of developmental as well as vascular, traumatic, inflammatory, metabolic, neurogenic and neoplastic origin. In regard to the parosteal lipomas reported in the literature, some of the misdiagnoses include: ganglion,³ osteosarcoma,²⁷ angioma,⁷ fibroma,⁷ and fibrosarcoma.⁷ It is interesting to note that in our 2 cases liposarcoma was the only lesion considered in differential diagnosis. On the basis of the roentgenograms all lesions mentioned above except liposarcoma can be excluded, since none produce a radiolucency.

Except for fibrosarcoma, the liposarcoma is the most common malignant soft tissue tumor of the thigh at this hospital. Its large size and relatively slow growth may mimic the parosteal lipoma. On physical examination, however, the liposarcoma is usually fixed only to the fascia, while the parosteal lipoma may be firmly attached to the underlying bone. Enlarged regional lymph nodes are occasionally observed in a liposarcoma, while this finding is absent in a parosteal lipoma. The patient with a liposarcoma may complain of pain and weight loss, symptoms which are rare in an individual with a parosteal lipoma. The roentgenograms may show areas of radiolucency in a liposarcoma, but many of these malignant tumors, unlike the parosteal lipoma, have the same roentgenographic density as the adjacent muscle. The presence of a hyperostosis adjacent to the radiolucent tumor would certainly favor the parosteal lipoma. At operation,

the liposarcoma may show pseudo-encapsulation by compressed fibrous tissue and thereby mimic the benign lesion. However, on cut section, the tumor is apt to show areas of mucoid consistency, and this change is not ordinarily seen in a parosteal lipoma.

MANAGEMENT

The treatment of parosteal lipoma is surgical. Preoperatively, the diagnosis will be almost certain if the patient has a long history of a slowly growing mass in one extremity, and the roentgenograms show a sharply defined radiolucency adjacent to the bone, associated with a hyperostosis. In this situation, the surgeon should enucleate the lipoma and remove the bony excrescence with the periosteal attachments.

When the mass has been present only a few months and has been growing rapidly, the possibility of liposarcoma should be considered, notwithstanding the presence of a radiolucent image on the roentgenograms. The treatment of a liposarcoma, of course, would be more radical. The appearance of the cut surface of the tumor may be helpful, as the lipoma is characteristically yellow and greasy, while the liposarcoma will usually be mucoid. A paraffin section will be necessary to separate the neoplasms. When it has been established that we are dealing with a benign lesion, the treatment is once again enucleation and resection of the regional periosteum. Closure of any dead space is important, and catheter suction drainage may be helpful to prevent any accumulation of blood. Periodic follow-up examinations are indicated, although a recurrence after complete removal is rare.⁸⁷ Malignant degeneration in parosteal lipomas has not been reported.

SUMMARY

A parosteal lipoma is a benign subfascial fatty tumor possessing an intimate connection with the adjacent periosteum. In a series of 32 parosteal lipomas, 16 had definite osseous abnormalities, either bowing, sclerosis, erosion or hyperostosis. The

usual history is that of a slowly enlarging nontender mass in one extremity of a patient forty to seventy years old. The pathognomonic roentgenographic findings are a soft tissue radiolucency adjacent to the bone with a hyperostosis. The most important lesion in differential diagnosis is the liposarcoma. If the parosteal lipoma is excised totally, the prognosis for cure is excellent.

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THE ROENTGENOLOGIC ASPECTS OF CHONDROMYXOID FIBROMA OF BONE*

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CHONDROMYXOID fibroma is a benign tumor of bone that apparently originates from cartilage-forming connective tissue. It has been recognized as an entity for only a short period. The histologic picture is distinct and relatively easy to diagnose for the experienced pathologist, but the lesion may be mistaken for chondrosarcoma by the unwary. The correct diagnosis of chondromyxoid fibroma of bone, although it may require the experience and skill of both pathologist and roentgenologist, will prevent unnecessary amputations.

REVIEW OF THE LITERATURE

In 1943, when reviewing their material on chondrosarcoma, Jaffe and Lichtenstein¹³ were impressed by a peculiar lesion of bone and mentioned 3 cases. Their first report on this new entity, which they called "chondromyxoid fibroma," did not appear, however, until 1948, when they reported 8 cases including the 3 mentioned earlier. They stressed that in the past such tumors were diagnosed as chondrosarcoma, chondromyxosarcoma or myxoma of bone.

Other reports^{2,5,6,8-12,17,18} corroborating the findings of Jaffe and Lichtenstein were published subsequently. In 1956, one of us (D.C.D.)⁴ added 10 previously unreported cases of chondromyxoid fibromas of bone, recorded 2 instances of this benign lesion that had recurred and emphasized the resemblance of this tumor to benign chondroblastoma in 3 cases.

Scaglietti and Stringa¹⁶ recently reported cases which they described as myxomas of bone. These lesions resembled

chondromyxoid fibromas, but since they were considered a different entity by these authors, we have not included them in the cases of chondromyxoid fibroma reported in the literature.

MATERIAL AND METHODS

The present study is based on 23 cases of chondromyxoid fibroma of bone. These include 15 cases from the files of the Mayo Clinic and 8 from elsewhere in which consultation was requested. Twelve of the cases were previously reported by us.⁴⁻⁶ The clinical history in each case was analyzed carefully. The roentgenograms or photographs of roentgenograms were available in 19 cases. In 4 others the study was based on the description made by the roentgenologist at the time of consultation. The well-preserved specimens were available in a few instances, and multiple sections were available for microscopic study in all 23 cases.

CLINICAL ASPECTS

Eighteen patients in this group were less than 30 years of age. The youngest was 6 and the oldest 54 (Table 1). This range in ages is in accord with that generally found in cases reported in the literature. Thirteen patients in this series were males, and 10 were females.

The long bones of the extremities were involved in 18 cases; 15 of the long bones involved were in the lower extremities. In 7 cases the lesions were found about the knee. The flat bones were involved in 5 instances: the innominate bone in 4, and the rib in one. The various sites of involvement

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TABLE I
AGE PER DECADE

Age (yr.)	No. of Cases
0-9	2
10-19	5
20-29	11
30-39	3
40-49	1
50-59	1

in our series are compared with those in the cases reported in the literature in Table II.

In the combined series of 47 cases, almost 80 per cent of the lesions involved the bones of the lower extremities. The bones of the upper limbs were affected in about 10 per cent. To date this tumor has not been reported as occurring in the humerus. The tibia was the site of involvement in more than 40 per cent of the cases.

Pain was present in all of our patients and was the reason for consultation in most of them. The duration of pain prior to consultation was several months as a general rule. Four of our patients had had pain for more than 2 years. Ten patients had observed swelling over the lesion, and 4 gave limp as a prominent feature. Many patients gave a history of recent or old trauma, but it was impossible to correlate the trauma with the appearance of the lesion. In one patient, however, a fracture was secondary to the chondromyxoid fibroma in a cuneiform bone.

PATHOLOGIC ASPECTS

Gross Findings. Grossly the lesions consisted of glistening, homogeneous, translucent material which often resembled cartilage. In other cases the lesions were more fibrous than cartilaginous, being firm and resilient.

As a general rule, the tumor appeared as a well-circumscribed whitish, grayish or bluish, ovoid lobulated mass. The cortex overlying the mass was commonly eroded, sometimes bulging and presenting some scalloping on the inner aspect. Bony tra-

beculations were not seen within the mass. In some instances, the lesion had perforated through the bony wall; however, the periosteum was intact in every case.

Microscopic Findings. As would be expected, the histologic picture of chondromyxoid fibroma had 3 basic components: chondroid, myxoid and fibromatoid. The lobular masses of tumor had variable amounts of these components. The chondroid tissue was composed of more or less immature-looking chondrocytes that appeared as small round cells with eosinophilic cytoplasm. These were often lying in lacunae. In several of these tumors, large and irregularly shaped nuclei simulated those seen in chondrosarcoma. The myxoid component contained stellate cells. These were embedded in a myxoid ground substance which contained variable amounts of collagen. The fibrous component, likewise, varied in amount. At times there was discrepancy between the gross fibrous appearance and the relative paucity of fibrous tissue found microscopically. In many instances a rather striking histologic feature was the increased concentration of nuclei observed at the periphery of the well-delineated lobules. Jaffe and Lichtenstein and one of us (D.C.D.) had observed this previously. As mentioned, the histologic picture in 3 of the cases appeared as a mix-

TABLE II
SITES OF INVOLVEMENT OF CHONDROMYXOID
FIBROMA

Bone Involved	Present Series	Literature	Total
Tibia	10	10	20
Femur	2	4	6
Pelvis	4	1	5
Metatarsal bones	2	3	5
Tarsal bones	1	1	2
Rib	1	1	2
Phalanx	1	1	2
Fibula	0	2	2
Ulna	1	0	1
Radius	1	0	1
Vertebra	0	1	1
Total	23	24	47

ture of chondromyxoid fibroma and benign chondroblastoma.

ROENTGENOLOGIC FINDINGS

The roentgenologic appearance of chondromyxoid fibroma of bone was that of a benign lesion. None of the lesions in our 23 cases was reported as being malignant on the basis of the roentgenologic findings. Table III gives the roentgenologic diagnosis made prior to operation. Many cases in this group were encountered before the entity was first described by Jaffe and Lichtenstein in 1948.

In 5 instances no diagnosis was made; in retrospect, however, 4 of these lesions had the appearance of a benign cystic lesion. In one case, it was not possible to evaluate the roentgenogram correctly because the lesion had been curetted elsewhere prior to admission, and the preoperative roentgenograms were not available for study.

The roentgenographic appearance of chondromyxoid fibroma was in almost all cases that of an ovoid-shaped radiolucent lesion. In one case, however, this cystic appearing lesion was not typical; the tumor involved a cuneiform bone and the picture was rather distorted by a fracture sustained by the patient while playing basketball.

The roentgenologic appearance of the lesions in the long tubular bones differed to some extent from that of lesions of the small tubular or flat bones. Tubular bones were the site of involvement in 18 of the 23 cases.

The Long Tubular Bones. The femur, tibia, fibula, ulna and radius were involved in 14 instances. The roentgenologic appearance of the majority of these lesions was characteristic.

The site of the lesion in these bones was typical. The lesion was not located in the epiphysis alone in any instance.

The epiphysis was not united in 5 of the 14 cases, and all the lesions were eccentrically placed. Two lesions involved the distal part of the tibia; both involved the metaphysis and extended into the adjacent diaphysis. In one of these cases, the

TABLE III
ROENTGENOLOGIC DIAGNOSIS PRIOR TO
OPERATION

	No. of Cases
Giant cell tumor	5
Bone cyst	5
Enchondroma	3
Benign lesion	3
Nonosteogenic fibroma	2
Description without diagnosis	5
Total	23

lesion also involved the epiphysis slightly (Fig. 1, *a* and *b* and 2, *a* and *b*). Three unusual lesions were seen in the proximal part of the tibia. These did not involve the metaphysis but seemed to have a close relationship with the base of the tibial tuberosity where there was growing cartilage from which the tumors probably arose (Fig. 3, *a* and *b* and 4).

The epiphysis was united in 9 cases, and in all but one the lesion appeared to be eccentrically located. In 3 patients in whom the epiphyseal line was still visible, the tumor was seen to originate definitively in its close proximity and to extend into the adjacent diaphysis (Fig. 5, *a* and *b* and 6, *a* and *b*). Here again the epiphysis was slightly involved in one patient. When the epiphyseal line could not be seen, the lesion was found on the diaphyseal side of the presumed epiphyseal line (Fig. 7, *a* and *b* and 8, *a* and *b*).

The cortex overlying the lesion appeared expanded and partially eroded from within in every instance of this group. In 7 cases it was completely perforated. When the cortex was destroyed, however, constant pressure from the growing mass seemed to be responsible rather than actual destruction or invasion of the bone by the neoplasm. In 3 other instances the cortex was so thin that it could hardly be seen.

The border of the bony defect in the long tubular bones was rather smooth with slight scalloped irregularity of contour occurring in many cases. There was no evidence of true trabeculations in these cases.

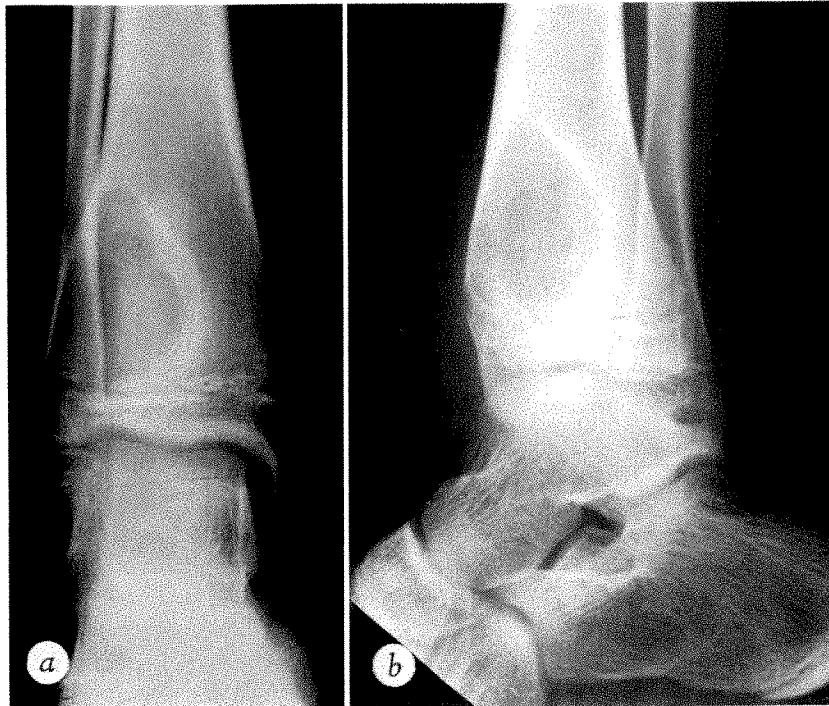


FIG. 1. Anteroposterior (*a*) and lateral (*b*) views of a chondromyxoid fibroma involving the distal metaphysis of the tibia. The epiphysis is not involved, the lesion is eccentrically located and the sclerosis that surrounds the defect is well seen. (Courtesy of Dr. R. V. Riddell, St. Joseph, Missouri.)

A well-defined medullary border was a prominent feature in this group and a definite rim of sclerosis was present in 10 instances.

The size of the lesions averaged 3 by 2 by 2 cm.

No periosteal reactions were evident on any of the roentgenograms. Stippled calcifications were seen in one tumor occurring in the distal end of the radius. The cortex of the bone was completely perforated, but the calcifications appeared to be restrained

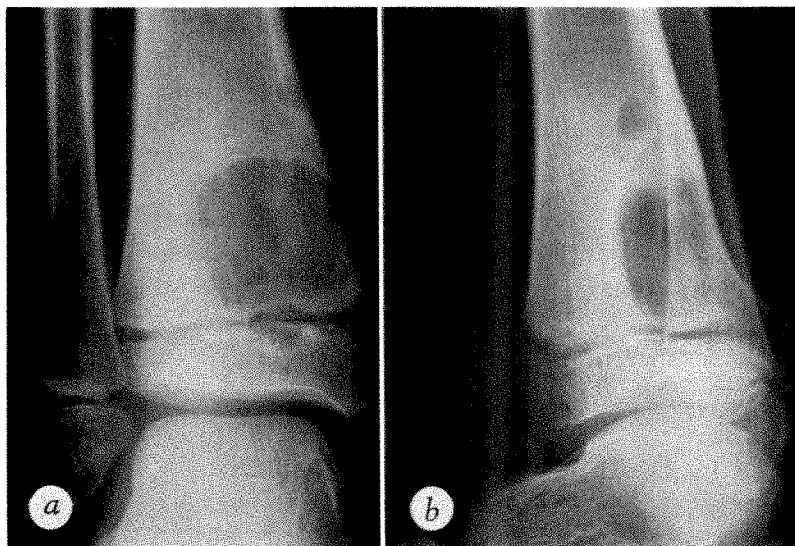


FIG. 2. (*a* and *b*) Eccentric lesion in the distal part of the tibia which has involved the epiphysis slightly. There is also a small similar lesion immediately above the large one.

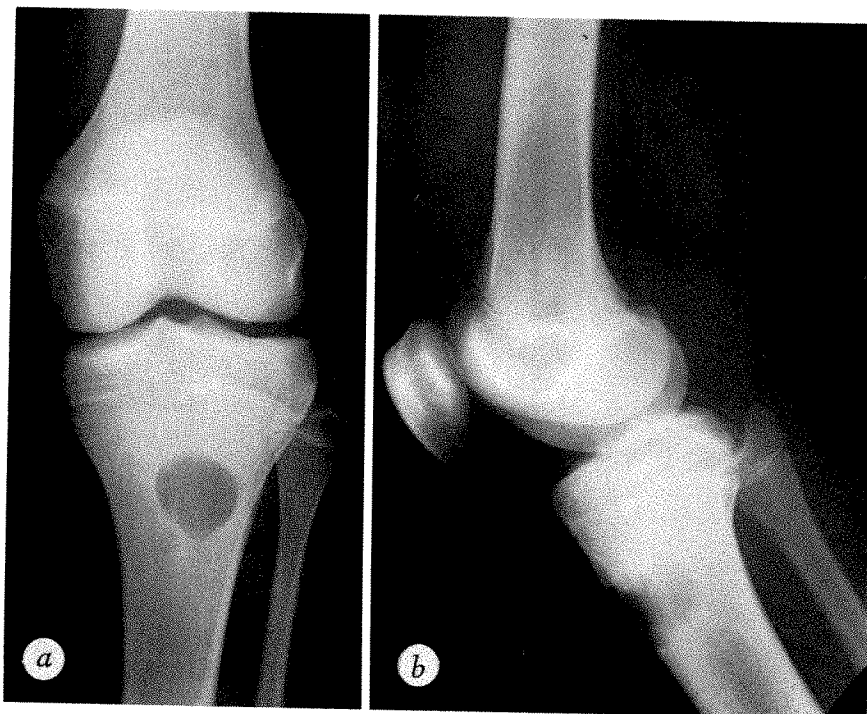


FIG. 3. (a and b) Typical lesion in the tibia in the region of the tuberosity which is strikingly similar to that shown in Figure 4.

by the periosteum (Fig. 9).

The Small Tubular Bones. These were the site of involvement in 4 patients: 2 in a metatarsal bone (Fig. 10), one in a tarsal bone, and the last one in the middle phalanx of the third finger (Fig. 11, a and b). Localization of the lesion within the bone was not characteristic. The lesion tended to involve the bone completely or a great portion of it and was centrally located in all instances. The overlying cortex was well expanded in every case and was perforated in one instance. In one patient with a lesion in a tarsal bone, the roentgenologic picture was distorted by a fracture.

The Flat Bones. These were involved in 5 instances: 4 in the ilium and one in a rib. The largest lesion in this present series was found in the ilium (Fig. 12). The contour

of the defect was irregular with marked scalloping. The general appearance was not characteristic.



FIG. 4. Chondromyxoid fibroma involving the proximal portion of the tibia in the region of the tuberosity. The lesion is eccentrically located, is well delineated by a sclerotic ring and appears to have originated from the base of the tibial tuberosity.

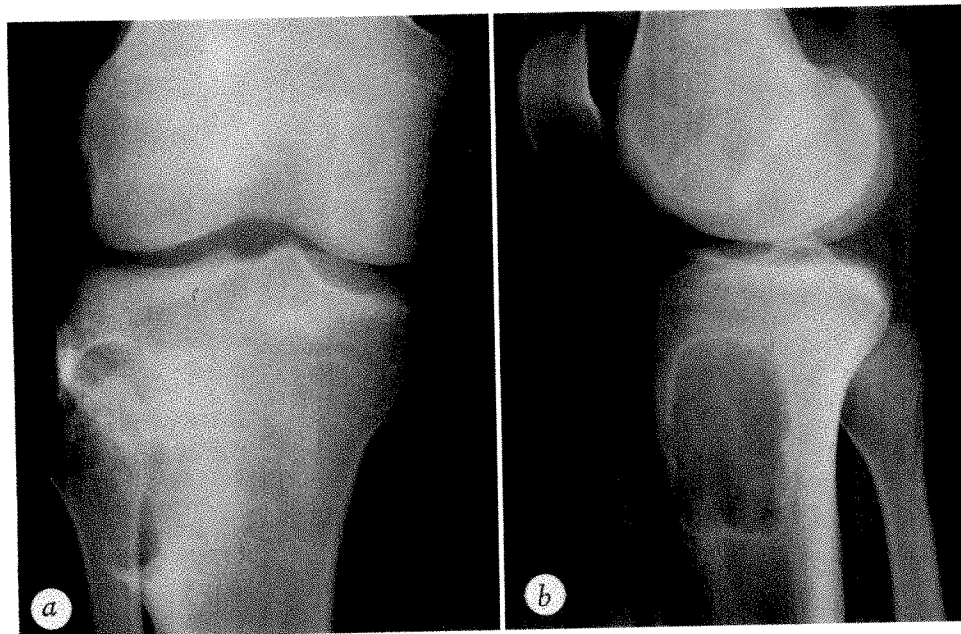


FIG. 5. (*a* and *b*) Chondromyxoid fibroma located in the proximal metaphysis of the tibia. The appearance is characteristic.

DIFFERENTIAL ROENTGENOLOGIC DIAGNOSIS

As it was noted previously, no cases in this series had roentgenographic signs that



FIG. 6. (*a* and *b*) Typical lesion in the distal part of the tibia. The epiphysis is spared; the defect is eccentrically located and delineated by a sclerotic border. (Courtesy of Dr. Lorel Stapley, Phoenix, Arizona.)

led to the diagnosis of malignancy. Consequently, the differential diagnosis from the roentgenologic findings alone must be made among benign conditions of bone. From the pathologic standpoint, the opposite holds true. The lesions in many instances displayed a false appearance of malignancy on microscopic examination.

Giant cell tumors, bone cysts, enchondromas, benign chondroblastomas, nonosteogenic fibromas, and aneurysmal bone cysts are the lesions to be considered in the differential diagnosis of chondromyxoid fibroma.

Giant cell tumors⁷ should not be too difficult to differentiate from chondromyxoid fibroma. Although they also have a predilection for long tubular bones, almost all giant cell tumors are located in the epiphyseal portion of the bone after the epiphysis and the diaphysis have united. They tend to invade and destroy the adjacent cortex more than chondromyxoid fibroma, and not too infrequently, involve the whole width of the bone. The medullary border of the tumor is indistinct and does not show the sharp demarcation seen in chondromyxoid fibroma. Chondromyxoid fibroma does not tend to extend across the

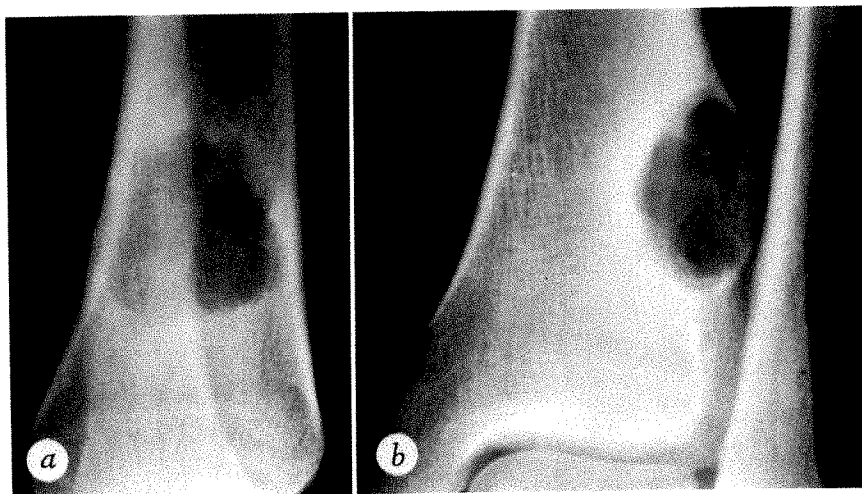


FIG. 7. (*a* and *b*) Chondromyxoid fibroma in the distal end of the tibia. The cortex is expanded and there is an appearance of septa in the defect, although septa do not actually exist. (Courtesy of Dr. William Tregoning and Dr. M. E. Thomas, Boise, Idaho.)

width of the bone unless it is involving a small cylindrical bone. Giant cell tumors are seldom seen in patients who are less than 20 years old, whereas chondromyxoid fibroma is rather frequently encountered in patients less than 20 years of age. The 2 neoplasms are readily differentiated microscopically by experienced pathologists.

Bone cysts¹⁵ occur in children and ado-

lescents. They are infrequently seen after 20 years of age. They affect the metaphysis of the long bone before the closure of the epiphyseal plate. They can be differentiated from chondromyxoid fibroma in that they are usually centrally located in the bone; they cause a fusiform widening of the cortex owing to the expansion of the cystic portion, and even though the cortex



FIG. 8. (*a* and *b*) Chondromyxoid fibroma involving the ulna. This was the only centrally located lesion affecting a long bone.

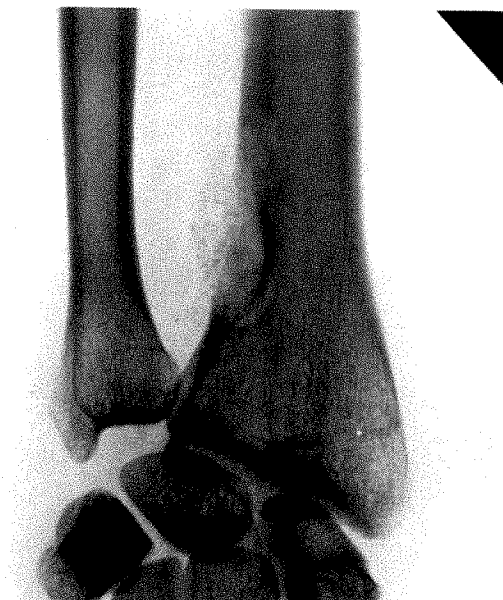


FIG. 9. Chondromyxoid fibroma of the radius. Note the presence of punctate calcifications which are limited by the periosteum. (Courtesy of Drs. G. T. Hranilovich, G. R. Dochat, Robert Fowler and Charles Miller, Akron, Ohio.)

is eroded and much thinned, one can always see a thin shell of bone unless there is a pathologic fracture.

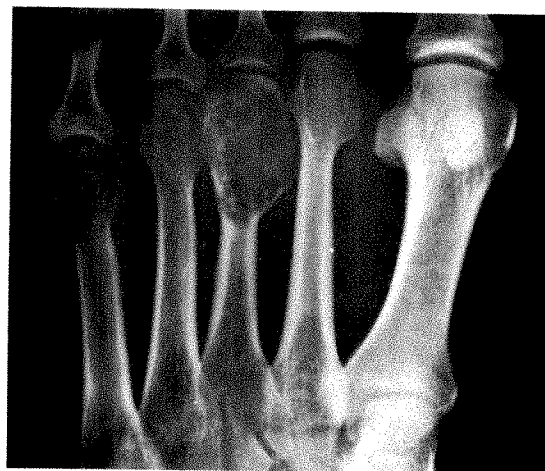


FIG. 10. Chondromyxoid fibroma originating from the distal end of the third metatarsal.

Enchondromas⁹ when they involve the small cylindrical bones are often multiple. If they affect the long bones, they tend to be centrally located. The presence of mottled calcifications, not infrequently seen in enchondromas, is a good differentiating sign because such calcifications are not seen in chondromyxoid fibroma.

Benign chondroblastomas¹⁴ are encoun-

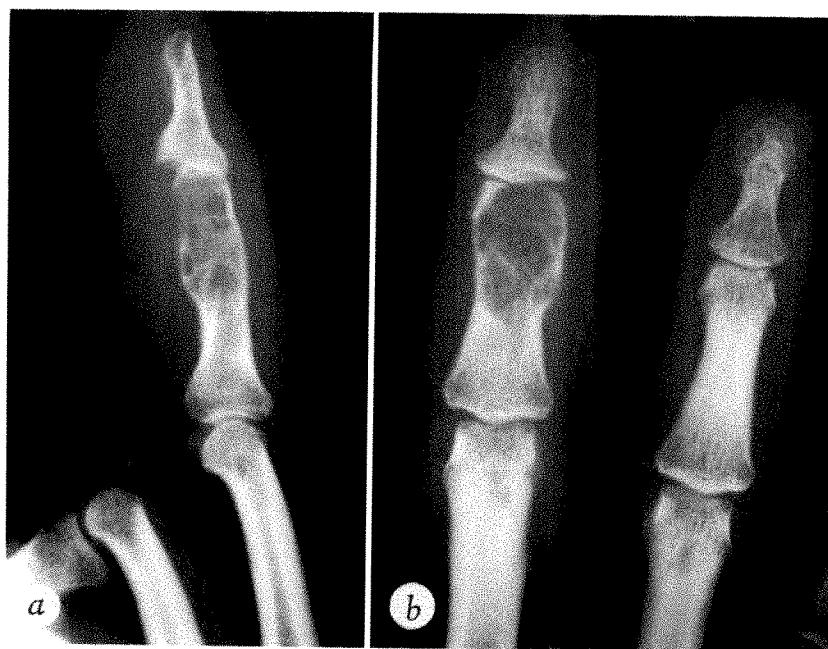


FIG. 11. (a and b) Cystic lesion involving the middle phalanx of the third finger. The lesion is centrally located and has expanded the cortex, which is completely eroded at the joint. (Courtesy of Dr. R. R. Williams, Middletown, Ohio.)

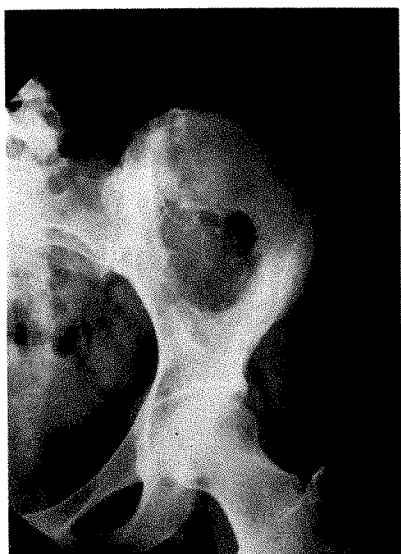


FIG. 12. Large defect in the ilium with a trabeculated appearance. (Courtesy of Drs. E. H. Boyer and J. A. Finer, Youngstown, Ohio.)

tered in the same age group as chondromyxoid fibroma; however, they are seen in the epiphysis only, occasionally abutting onto the metaphysis. They may involve the head of the humerus where chondromyxoid fibroma has never been reported. They may show mottled calcification in some instances and periosteal reaction at times. These 2 findings were not seen in our group of chondromyxoid fibromas.

Nonosteogenic fibroma⁵ presents itself as a small eccentric radiolucent defect located in the diaphysis of a long bone. It is generally small, and the sclerotic ring surrounding the lesion is usually more marked than that seen in chondromyxoid fibroma. It does not tend to expand the bone to the degree that a chondromyxoid fibroma does.

Aneurysmal bone cyst⁶ occasionally may resemble chondromyxoid fibroma, but the typical soap bubble appearance, the marked bulging of the cortex, and the rather prominent trabeculations are lacking in chondromyxoid fibroma. A good sign in differentiation is the condition of the medullary border of the lesion. This is hazy and ill-defined in aneurysmal bone cyst and is well delineated in chondromyxoid fibroma by a characteristic sclerotic rim.

TREATMENT AND PROGNOSIS

The majority of the patients in this series was treated by curettage and cauterization, or curettage and packing of the cavity with bone chips. Amputation was the treatment in 2 cases, in one because of an original pathologic diagnosis of osteogenic sarcoma for a lesion of the ulna and in one because of a pathologic diagnosis of chondrosarcoma in a tibial lesion. Operations were performed on both of these patients before chondromyxoid fibroma was recognized as a distinct pathologic entity. Roentgen therapy was given to one patient because of the wide extension of the neoplasm and the impossibility of complete surgical removal without a wide excision. Partial resection was done in 3 instances in which the small bones were involved. Two lesions were in the metatarsals and one in a rib.

There were 3 examples of recurrence in this group. In one patient the lesion recurred twice, but there was no evidence of tumor 3 years after the last operation. In the other 2, recurrences were treated by curettage, and the patients were well 7 and 2 years after treatment.

Follow-up information was obtained from 19 patients. It was complete for 12 of them. In the other 7, the patients could not be traced after a certain period, or the interval between operation and last contact with the patient was too short to be of any significance. One patient died 8 years after operation from generalized lymphoma. All other patients were well 6 months to 18 years after treatment.

COMMENT

So far, including this present series, 47 examples of chondromyxoid fibroma have been reported in the literature. With such a small number of cases, definite conclusions with regard to the various roentgenologic manifestations of this tumor are not possible. However, an attempt has been made to summarize the nature of this tumor so far as can be determined.

The origin of chondromyxoid fibroma of bone is not well known. The consensus is

that it originates from cartilage-forming connective tissue. The close histologic relationship between chondromyxoid fibroma and benign chondroblastoma was pointed out by one of us (D.C.D.) in 3 cases. Aegerter and Kirkpatrick¹ were of the opinion that these 2 benign conditions of bone probably arise from the epiphyseal plate, the chondromyxoid fibroma growing mainly in the metaphysis, whereas the benign chondroblastoma involved the epiphysis.

The clinical aspect does not help in the diagnosis of chondromyxoid fibroma. The symptoms and signs commonly seen in many other conditions of bone may be encountered, namely: pain, swelling and tenderness on pressure. The age of the patients in this group averaged 23 years. More than 80 per cent of the patients were less than 30 years of age. This is in accordance with the age incidence recorded in the literature. However, this tumor can occur at almost any age. It has been reported in patients as young as 6 years and as old as 56. The sex incidence is not significant since both sexes are affected equally. The duration of symptoms prior to operation has ranged from 2 months to 3 years, indicating that in many instances it is a slowly growing lesion.

The roentgenologic appearance often shows characteristic features. This is particularly true when the tumor is found in the long bones. It is seen as a well defined area of radiolucency eccentrically located in the diaphyseal side of the epiphyseal plate and presenting a characteristic sclerotic rim in its internal border. The lesion may abut onto the epiphysis. The cortex overlying the lesion is eroded in most instances and not infrequently it is completely perforated. No periosteal reaction is visible on the roentgenograms. In the "myxomas of bone" reported by Scaglietti and Stringa,¹⁶ periosteal reaction was observed adjacent to the tumor and since these cases may represent a more aggressive form of chondromyxoid fibroma, one might expect to see this type of periosteal reaction occasionally.

In the small cylindrical bones, the lesion tends to be centrally located with prominent bulging of the cortex. The process is relatively more extensive than in the long bones. In the flat bones the lesion is lacking in distinguishing characteristics. The defects are larger and the appearance of loculation is more conspicuous than in tubular bones.

From this study it became apparent that the roentgenologic appearance of chondromyxoid fibroma is that of a benign lesion, often presenting characteristic features. In a typical case, one should be able to differentiate it from other benign lesions such as giant cell tumor, bone cyst, enchondroma, aneurysmal bone cyst, and benign chondroblastoma.

The problem of differential diagnosis is different from the pathologic viewpoint. As Jaffe and Lichtenstein¹³ have pointed out in their first report, chondromyxoid fibroma is often mistaken for a malignant lesion and this was true in 5 patients in our series. In 3, the lesions were reported originally as low-grade chondrosarcoma, in one as chondromyxosarcoma, and in one as osteogenic sarcoma. In 2 of these patients amputation was performed. Only a local excision was done in the other 3 patients because of the diagnosis of low-grade malignancy. These diagnoses were made, however, before the first description of chondromyxoid fibroma by Jaffe and Lichtenstein in 1948.

The histologic picture appears characteristic to the experienced pathologist, and the presence of round acidophilic and spindle-shaped cells interspersed loosely in a myxoid matrix should make one suspect this lesion.

The roentgenographic and the gross appearance of chondromyxoid fibroma are closely related. This was described well by Jaffe and Lichtenstein in their original report. "The tumor destroys the bone at the site of its growth and residua of the original spongy trabeculae are not usually found within it. Where it abuts on cortex, it tends to erode and destroy it and as the original cortex gives way, the contour of

the affected area of the bone becomes bulged. The expanded contour may be outlined, in part or throughout, by a thin shell of bone newly deposited by the periosteum. However, where there is no shell, the tumor is still contained by the periosteum. The tumor does not extend across the entire width of the bone at the site of its growth."

The treatment of choice for chondromyxoid fibroma is complete curettage or excision of the lesion and packing of the defect with bony chips, if necessary. The prognosis is good. In 3 of our cases the lesion recurred, and a few instances of recurrence have been reported in the literature. In all instances the recurrence was due to an incomplete surgical removal rather than a natural tendency for the tumor to recur. In one case reported by Iwata and Coley,¹¹ the lesion recurred as chondrosarcoma. It is too soon to draw any conclusions from this case alone.

SUMMARY

The clinical records in 23 cases of chondromyxoid fibromas encountered at the Mayo Clinic or seen in consultation were reviewed. Roentgenologic study in these cases revealed that all the tumors appeared benign on the roentgenograms. Characteristic roentgenologic findings were observed in 50 per cent of the cases. Pathologically the lesion is easily mistaken for a malignant condition of bone such as chondrosarcoma. Treatment consists in curettage and packing with bony chips if necessary.

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MELORHEOSTOSIS AND OSTEOPOIKILOSIS*

WITH A REVIEW OF THE LITERATURE

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MELORHEOSTOSIS Leri and osteopoikilosis, two somewhat rare disorders of bone, have attracted the attention of roentgenologists since their discovery by Leri and Joanny²⁵ in 1922 and by Steida¹¹ in 1905. Since the initial descriptions of these conditions, isolated case reports and periodic reviews of the literature have been presented. The more recent complete reviews are those of Spiegel and Koiransky²⁵ in 1950 and of Harmston¹¹ in 1956.

The purposes of this paper are to bring the total number of reported cases up to date, to present our own cases, and to discuss the similarities and differences between the two conditions.

The roentgenograms and clinical files of the USAF Hospital Lackland, Lackland Air Force Base, Texas, and Brooke Army Hospital, Fort Sam Houston, Texas, have been reviewed. We are reporting 8 cases of melorheostosis and 8 cases of osteopoikilosis. The roentgenograms of these cases are also presented.

Composite summaries of all cases previously reported in the world medical literature are given in tabular form (Tables I and II). Articles appearing or abstracted in the English literature have been reviewed carefully and the roentgenologic findings verified where possible. Foreign language reports are listed in the composite summary totals, but have not been studied for verification.

MELORHEOSTOSIS LERI

HISTORY

In 1922, the French physicians—André

Leri and J. Joanny—described the first case of a peculiar hyperostosis distributed on the side of a bone. This bony sclerosis resembled the tallow drippings on the side of a burning candle. They created the name “melorheostosis” for this abnormality from the Greek terms for limb, flow and bone.

Other synonyms for this disorder that have appeared in the literature are: hyperostose en coulée de bougie, osteosis eburnisans monomelica, and osteopathia hyperostotica congenita membri unius.

GENERAL CONSIDERATIONS

The etiology of this unusual disorder is unknown. Most authors deny hereditary or familial tendencies. There is no sex predisposition. The youngest patient previously reported afflicted with this disease was five years of age; the oldest, fifty-nine years.³ We now present a case discovered at the age of three years (Fig. 7).

Among the theories on the origin of melorheostosis Leri have been: bacterial, mycotic or parasitic infection; angiospasm due to imbalance of the autonomic nervous system; endocrine disturbances; derangement of calcium metabolism; subperiosteal telangiectasis; and abnormal development of the anlage bud of the part involved.

CLINICAL SYMPTOMATOLOGY

This condition may be discovered as an incidental finding with no clinical manifestations referable to the pathologic process. The most common complaint is pain, of varying type and degree, depending on the sites of involvement, extent of the process and activity of the lesion. The patient's complaint may vary from a vague “aching”

* This paper represents the personal point of view of the authors and is not to be construed as official Air Force or Army policy.

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TABLE I
COMPOSITE SUMMARY OF CASES OF MELORHEOSTOSIS LERI
Total cases as reported by Spiegel and Koiransky,²⁵ 1950: 50
Cases reported originally 1950-1960

Authors	Year	Age	Sex	Location	Symptoms	Comments
Hess and Street ¹³	1950	51	M	Rt. upper extremity	Pain	Thoracic sympathectomy
Koulumies ¹⁶	1950	35	F	Rt. thumb, radius, multi- anguli	Pain	Injury as child
Murray ²²	1951	43	M	Lt. sacroiliac, femur, tibia, scapula, ribs, vertebrae	Pain	Exfoliative dermatitis of left ankle 10 yr.
O'Connell ¹⁹	1951	18	F	Rt. hip, femur, tibia, metatarsus	Hip pain	Erysipelas of rt. leg at age 4 yr.
Thompson <i>et al.</i> ²⁷	1951	10	F	Rt. lower extremity	Pain, contraction deformities of knee, ankle	Scleroderma, expired post biopsy of fat embolism
Boecker ³	1951	29	M	Lt. upper extremity	Pain	
Boecker ³	1951	27	M	Rt. femur, patella		
Höffken and Heim ¹⁴	1951	20	M	Skull, ribs, rt. upper extremity		
Shapiro <i>et al.</i> ²³	1953	45	F	Lt. upper extremity, scapula		Attempt at surgical excision
Elkeles ²	1954	—	—	Pelvis, sacrum, all 4 extremities		
Siler ²⁴	1954	37	F	Rt. 4-5th fingers, ulna	Pain, tumor	Slow progression over 8 yr.
Campbell ⁵	1955	26	M	Rt. upper extremity	Pain, stiffness of thumb and shoulder	Progression in 1 yr. to involve scapula
Morton ²⁰	1957	63	M	Rt. ulna, carpals, metacarpals, phalanges	Flexion deformity of elbow and wrist	
Mulla ²¹	1958	38	F	Pelvis, rt. tibia	Pain, rt. lower quadrant during pregnancy	
Green, Ellswood and Collins—Case I	1961	28	M	Lt. lower extremity	Pain	
Green, Ellswood and Collins—Case II	1961	37	F	Both femora	Pain	Slight progression in 4 yr.
Green, Ellswood and Collins—Case III	1961	20	M	Both femora	Asymptomatic	
Green, Ellswood and Collins—Case IV	1961	25	M	Lt. wrist, hand, carpals, metacarpal, phalanges	Pain, enlargement of index finger	
Green, Ellswood and Collins—Case V	1961	42	M	Lt. lower extremity	Pain, lt. lower extremity 1½ inches longer than rt.	
Green, Ellswood and Collins—Case VI	1961	19	M	Rt. lower extremity	Pain	(Roentgenograms could not be reproduced for illustration.)
Green, Ellswood and Collins—Case VII	1961	8	M	Rt. pelvis, lower extremity	Abdominal pain	
Green, Ellswood and Collins—Case VIII	1961	3	M	Lt. lower extremity		Youngest case reported
Total cases reported and verified, 1922-1961					73	
Foreign literature reports as of December, 1960					33	
Total cases					106	

to a rather severe cramp-like pain, which may be aggravated by activity and relieved by rest.

The involved extremity may be shorter, or less frequently longer than the normal uninvolved member. Deformities of limbs and muscle wasting may be present. The process tends to skip over joint areas but stiffness and loss of joint mobility are occasional findings.

SITES OF OCCURRENCE

Initially, it was thought that the disorder was confined to a single limb; however, there are increasing numbers of cases showing multiple and bilateral limb involvement. Lesions have been reported in the upper and lower extremities, pelvis, shoulder girdle, spine and skull. The long bones of the extremities are by far the most frequent sites of involvement. Many cases

TABLE II
COMPOSITE SUMMARY OF CASES OF OSTEOPOIKILOSIS
Total cases as reported by Harmston,¹¹ 1956: 86
Cases reported originally 1956-1961

Authors	Year	Age	Sex	Comments
Fairbank ⁷	1948	21	M	
Martincic ¹⁸	1952	25	M	
Fisk ⁹	1953	26	M	
Aigner ¹	1953	14	F	Palmar and plantar keratoses
Aigner ¹	1953	—	F	Palmar and plantar keratoses
Ferreri ⁸	1954	21	F	Annular condensation in femoral metaphysis
Appelman and Moehlig ²	1954	63	F	Hyperostosis frontalis interna
Appelman and Moehlig ²	1954	41	F	Hyperostosis frontalis interna
Hartig ¹²	1955	—	M	Cleft palate
Hartig ¹²	1955	—	M	Cleft palate
Jonasch ¹⁵ (12 cases)	1955		(son)	4 cases with skin lesions
Uebelhart <i>et al.</i> ²⁸	1958	35	M	
Weissmann ²⁹	1958	35	M	Scleroderma
Melnick ¹⁹ (17 cases)	1959			3 generations, same family
Allen ²⁶ (2 cases)	1960			Dermatofibrosis lenticularis
Green, Ellswood and Collins—Case I	1961	27	M	
Green, Ellswood and Collins—Case II	1961	23	F	Dermatofibrosis lenticularis
Green, Ellswood and Collins—Case III	1961	30	M	
Green, Ellswood and Collins—Case IV	1961	17	M	
Green, Ellswood and Collins—Case V	1961	20	M	
Green, Ellswood and Collins—Case VI	1961	19	M	
Green, Ellswood and Collins—Case VII	1961	37	F	
Green, Ellswood and Collins—Case VIII	1961	27	F	
Total cases reported and verified, 1905-1961				137
Foreign literature reports as of December, 1960				28
Total cases				165

have shown involvement of a part or all of one extremity. The process often will involve only one side of a bone and will be sharply demarcated from normal bone.

ROENTGENOLOGIC APPEARANCE

This disorder presents a striking roentgenologic picture, consisting of linear bone sclerosis, chiefly cortical but also extending into the medullary portion of bone. The dense hyperostosis with linear distribution mainly on one side of a bone or bones and the irregular waxy outline are characteristic. In addition, small bone deposits may

be seen in the soft tissues, especially in the joint regions. In membranous bones and the epiphyses of long bones, the deposits are often small, dense, irregular areas of sclerosis. This latter finding is often confused because it closely resembles the "spotting" of osteopoikilosis. Partly because of this, some authors have speculated that melorheostosis and osteopoikilosis may be the same basic disease.

PATHOLOGY

Biopsy and autopsy material has shown on gross examination a condition of osteo-

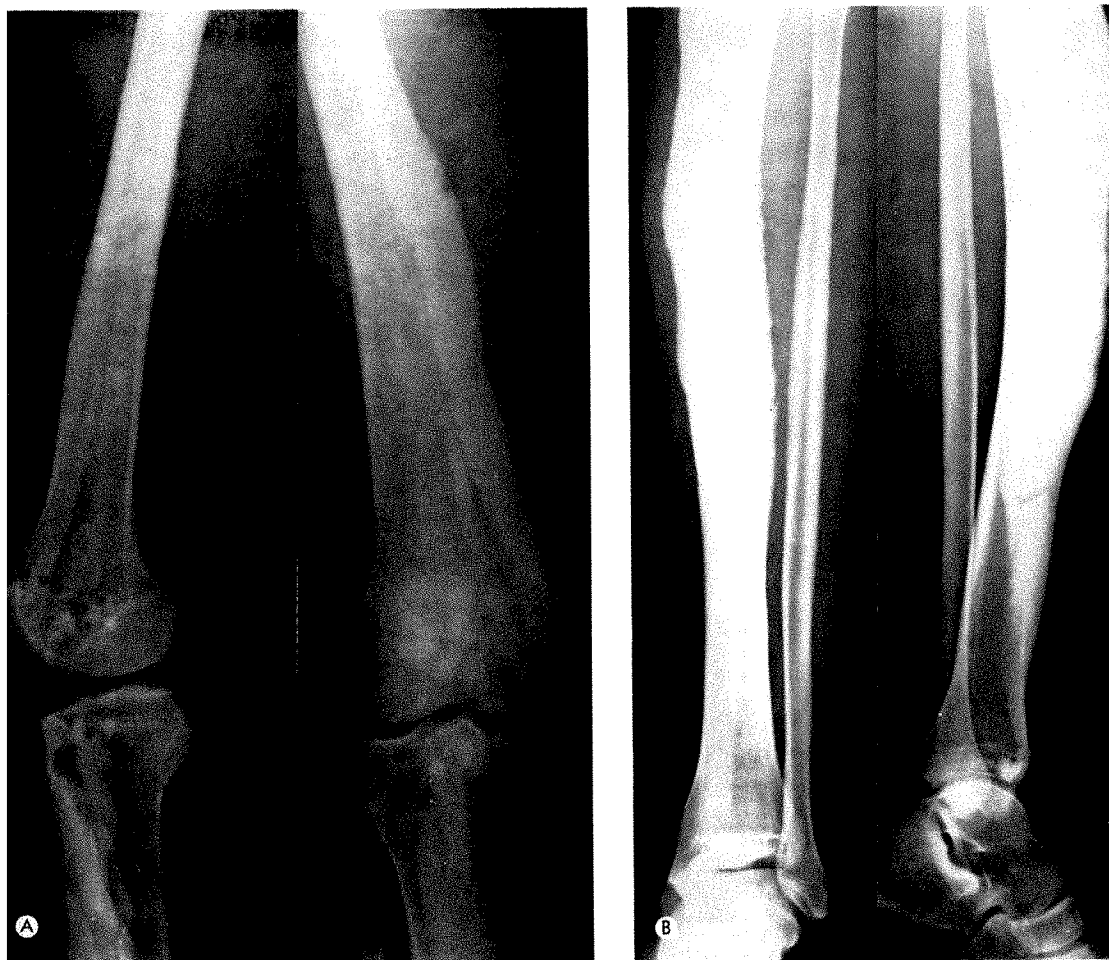


FIG. 1. (A and B) Melorheostosis (Case 1). Typical changes of flowing, tallow-like, linear sclerosis of femur and tibia. Note soft tissue densities at knee. Unilateral involvement. (LogEtronic reproduction.)

sclerosis with irregularly shaped eburneous foci in the bone. The changes are seen along the diaphyses and in the epiphyses, usually along one side of the bone. The new bone formation may result in large tumor masses.

Histologic examination shows the basic Haversian system to be intact. There is fibrotic infiltration of the trabecular structure and fibrotic replacement of the marrow. There is no evidence of inflammation. The status of the osteoblasts was differently interpreted by the various observers. Putti described obliteration of capillaries in his specimens.²⁵ He considered this finding to



FIG. 1. (C) Similar changes in the tarsals and first metatarsal.

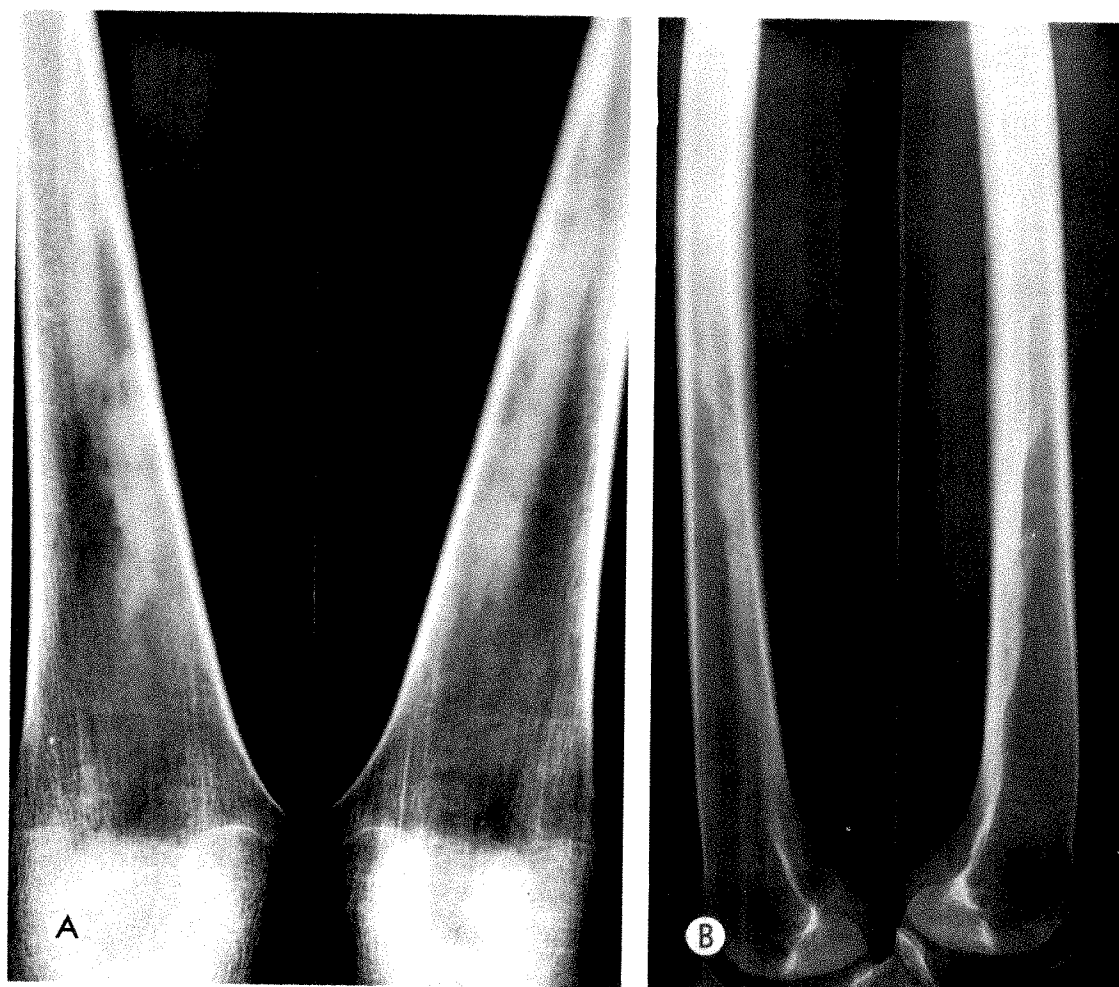


FIG. 2. (A and B) Melorheostosis (Case 11). Bilateral linear, irregular sclerosis of posterior femoral shafts. Pain localized to areas. Slight progression noted on four year follow-up roentgenograms.

be a sign of ischemia, possibly explaining the etiology of the disorder.

PROGNOSIS

Melorheostosis Leri is characterized by an insidious onset and a slow, chronic course with periods of exacerbation and arrest. Many cases have shown progress of the bone process in a single bone and other skeletal areas. Infrequent cases have been incapacitating, requiring sympathectomy for relief of pain.¹³ The disease has shown no response to specific therapeutic agents; radiation therapy does not alter the course of the disease. To date no report of malignant degeneration in the involved bone has been noted.

OSTEOPOLKILOSIS

HISTORY

In 1905, the German surgeon—Alfred Steida—described the first patient found to have this disorder. Roentgenograms showed “a circumscribed condensing of bone in the region of the substantia propria” and on microscopic examination this was found to be “composed of compact islands of corpuscles and lamellae in irregular arrangement.”¹⁹ In 1915, Heinrich Albers-Schönberg reported a similar case in a twenty-two year old soldier. His name has been associated with this disease, but most authors have advised dropping the eponym because of the possible confusion with



FIG. 3. (A and B) Melorheostosis (Case III). Bilateral distal femoral sclerosis in asymptomatic young male. Note similarity to Case II.

osteopetrosis (marble bones). In 1916, Ledoux Lebard *et al.* coined the term "osteopoikilie" (spotted bones).¹⁹

Many synonyms have been used in reporting this bone disorder. Among these are: osteopoikilosis, osteopecilia, osteodermato-poikilosis, osteitis condensans generalisata, osteosclerosis generalisata, and osteopathia condensans disseminata. We prefer the older name—osteopoikilosis—since it is most descriptive of the roentgenographic findings.

GENERAL CONSIDERATIONS

Osteopoikilosis occurs most commonly

between the ages of fifteen and sixty. Heiborn reported a case in a fetus four months of age; Keyser in a newborn; and von Bernuth in an infant eighteen days old. Four cases have been described in persons over sixty-five—ages sixty-eight, seventy, seventy-three and seventy-four.¹⁹ Both sexes are affected although there is slight predominance in the male.

The etiology of this bone disorder is unknown. There is a strong hereditary tendency. Voorhoeve was the first to report the multiplicity of cases in a single family—father, son and daughter.¹¹ Melnick¹⁹ discovered 17 persons in three generations of a



FIG. 4. (A, B and C) Melorheostosis (Case IV). Dense sclerosis of phalanges, metacarpal and carpals (unilateral). Painful enlargement of index finger of several years' duration. Note soft tissue density on dorsum of wrist. (LogEtronic reproduction.)

family; a possible individual in the fourth generation may be affected and is being studied. Genetically, the disease appears to be associated with a dominantly inherited autosomal gene.

Most reported cases have been found accidentally on roentgenograms taken for other purposes. As would be expected in an unusual disease, a multitude of associated conditions has been reported with

osteopoikilosis. These include dermatofibrosis lenticularis disseminata, cutaneous and subcutaneous fibrous nodules, scleroderma, hyperostosis frontalis interna, cleft palate, syndactyly, dwarfism, venous thromboses, diabetes mellitus, syphilis, parathyroid and other endocrine abnormalities.

Patients with osteopoikilosis exhibit no specific clinical symptoms or signs refer-



FIG. 5. (A and B) Melorheostosis (Case v). Massive flowing sclerosis of femur and fibula. Severe pain; extremity $1\frac{1}{2}$ inches longer than opposite member. (LogEtronic reproduction.)

able to the bone lesions. Laboratory studies show no alteration of the hemogram, urinalysis, calcium-phosphorus, or phosphatase indices.

SITES OF OCCURRENCE

The predominant sites of location of the bone abnormalities are: pelvis, metaphyses and epiphyses of long bones, and small bones of the carpus and tarsus. Every bone in the skeleton has been incriminated. However, lesions of the calvarium, facial bones, mandible, ribs, sternum, and verte-

brae are most unusual. Location of lesions in the diaphyses of long bones has not been reported. This is an important fact in differentiating the bone lesions of osteopoikilosis and melorheostosis.

ROENTGENOLOGIC APPEARANCE

As previously stated, the term "osteopoikilosis" (spotted bone) remains the most accurate description of the abnormality seen on the roentgenogram. The "spots" are numerous, small foci of bone sclerosis, varying in size from a few millimeters to

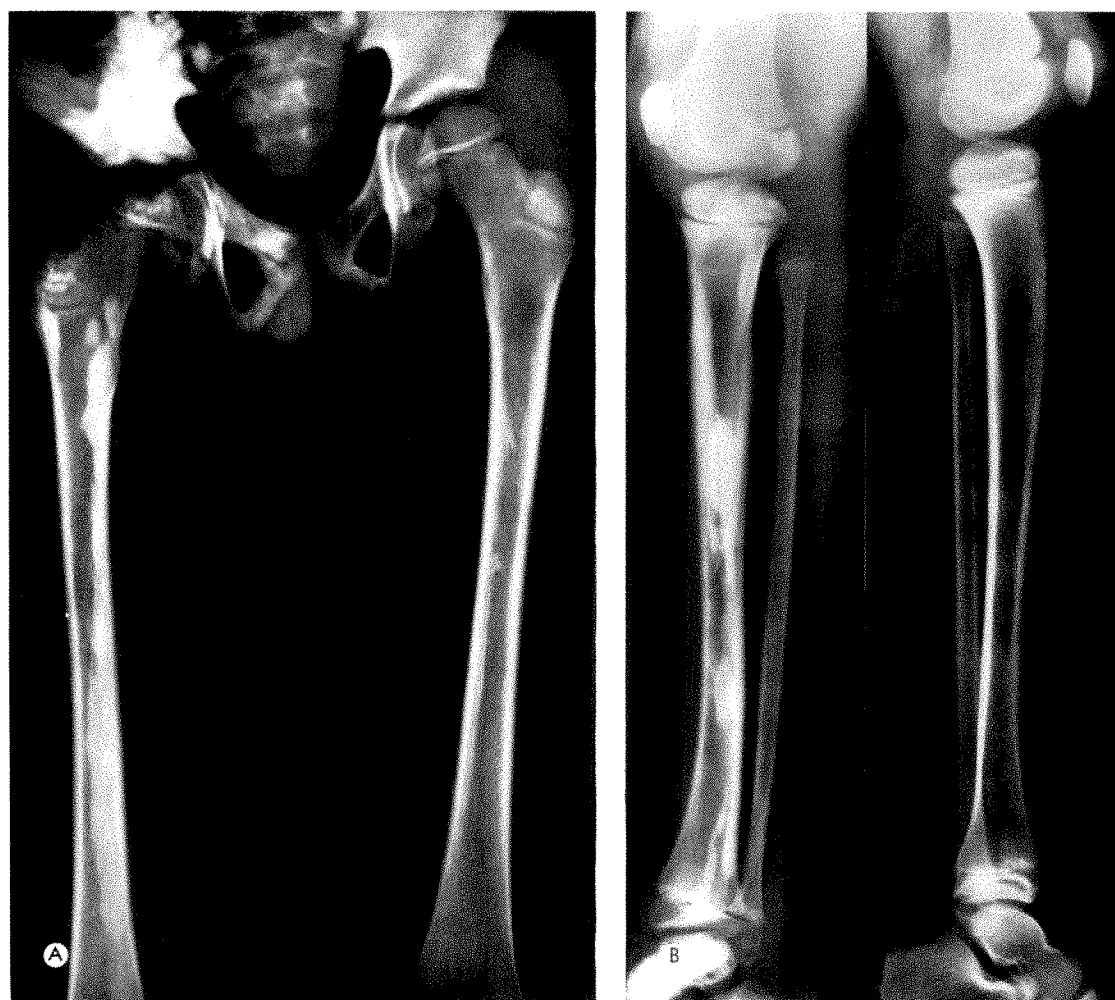


FIG. 6. (A and B) Melorheostosis (Case VII). Eight year old male. Flowing hyperostosis of pelvis and right lower extremity. Note early changes in left femur. (LogEtronic reproduction.)

several centimeters. Three general types of configuration may be seen: (1) lenticular—round, oval, or nodular densities; (2) linear-striated or oblong densities; and (3) mixed. No soft tissue or joint calcification is seen.

PATHOLOGY

The classic histopathologic description of osteopoikilosis was made by Schmorl in 1931. He wrote of the lesions as "an increased density, the result of numerous bone trabeculae of various thicknesses arranged rather regularly, the bone resembling the structure of spongiosa and not cortex. Individual trabeculae were slightly

thicker than normal bone and gave the impression of compact bone. Trabeculae merged into the surrounding structures gradually, disappearing among those of normal spongiosa. The thicker trabeculae consisted of lamellar bone with a parallel arrangement for the most part, but in a few instances they were arranged concentrically around blood vessels without, however, leading to the "picture of osteoma."¹⁹ These findings have been confirmed by several authors on autopsy and biopsy specimens. No evidence of inflammation, necrosis or malignant degeneration has been reported.

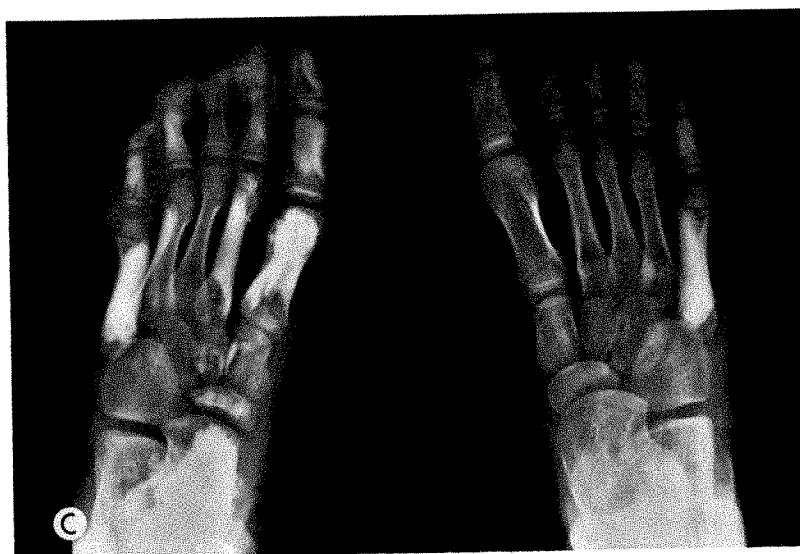


FIG. 6. (C) Involvement of feet. Note advanced sclerosis of bones of left foot.

PROGNOSIS

Osteopoikilosis is not considered a morbid disease. There is little symptomatology, no incapacitation or debility. Several cases have been followed for numbers of years and little change in the roentgenographic appearance has been noted. Only a few cases have shown progression of the sclerotic foci in a single site or "spread" to

involve other skeletal areas. Specific therapeutic measures, including radiation therapy, cause no change in the disease process.

DISCUSSION

Over the years in discussions of melorheostosis Leri and osteopoikilosis, the question of relationship between the two diseases has frequently arisen. In reporting

TABLE III
COMPARISON OF FINDINGS IN MELORHEOSTOSIS AND OSTEPOIKILOSIS

	Melorheostosis Leri	Osteopoikilosis
Age Occurrence	Any age	Any age
Sex Occurrence	Either sex	Either sex
Etiology	Unknown	Unknown
Hereditary or Familial Tendency	None	Yes
Symptomatology	Pain, limitation of joint motion, debility	Usually none
Associated Conditions (skin, systemic diseases)	Few cases, no consistent finding	Many cases, dermatofibrosis lenticularis, subcutaneous nodules, cleft palate
Sites of Occurrence	Shafts of long bones; small bones of hands and feet; eccentric; usually unilateral	Membranous bones; small bones of hands and feet; ends of long bones; symmetric
Roentgenographic Appearance	Flowing, linear hyperostosis; soft tissue calcification common	Small, spotty foci of sclerosis; no soft tissue calcification
Treatment	None specific; sympathectomy for pain relief	None specific
Prognosis	May progress in same or other bones	No progression

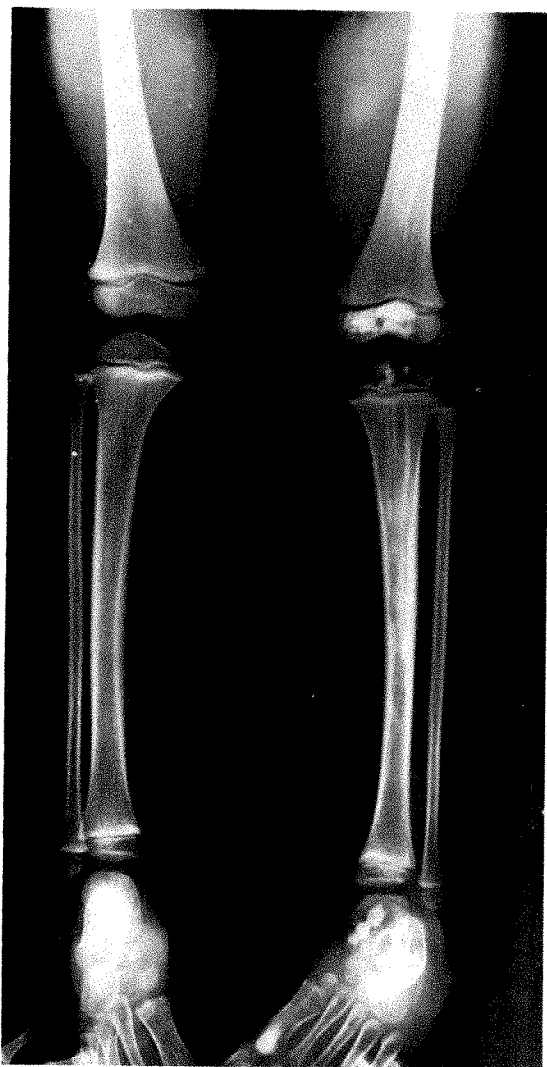


FIG. 7. Melorheostosis (Case VIII). Three year old boy with linear sclerosis of femur, tibia and punctate foci in distal femoral epiphysis, proximal tibial epiphysis, talus and first metatarsal. (Log-Etronic reproduction.) Note similarity to Case VII.

a case of one of the diseases, the other is usually mentioned as a possibility in differential considerations. Several authors, including Albers-Schönberg,¹⁷ Caffey,⁴ and Boecker,³ have offered the opinion that these two diseases may represent a single basic process. In reviewing our cases and the literature, we too have noted similarity of these diseases in some patients. However, in most cases a definite diagnosis can be made on the basis of the roentgeno-



FIG. 8. Osteopoikilosis (Case I). Typical appearance of multiple sclerotic foci (spotting) of humerus, scapula, clavicle and ribs. Note confluent sclerosis along medial cortical shaft of humerus—resembles melorheostosis. (Log-Etronic reproduction.) Pelvis, hips and opposite shoulder also involved.

graphic appearance and clinical findings.

Of our 16 cases of these two disorders, a clear-cut diagnosis can be made in all patients on the basis of roentgenographic findings. The 2 cases of melorheostosis Leri occurring in children (Cases VII and VIII) show predominant linear hyperostosis of the flowing type in the extremities. However, small sclerotic foci are seen in the epiphyses and tarsals. These findings closely resemble osteopoikilosis. Caffey⁴ reported similar findings in an eighteen year old boy. We feel that these cases should be classified as melorheostosis Leri on the



FIG. 9 Osteopoikilosis (Case II). Patient had widespread involvement of pelvis, hips, sacrum, vertebrae, wrists and ankles. (LogEtronic reproduction.)

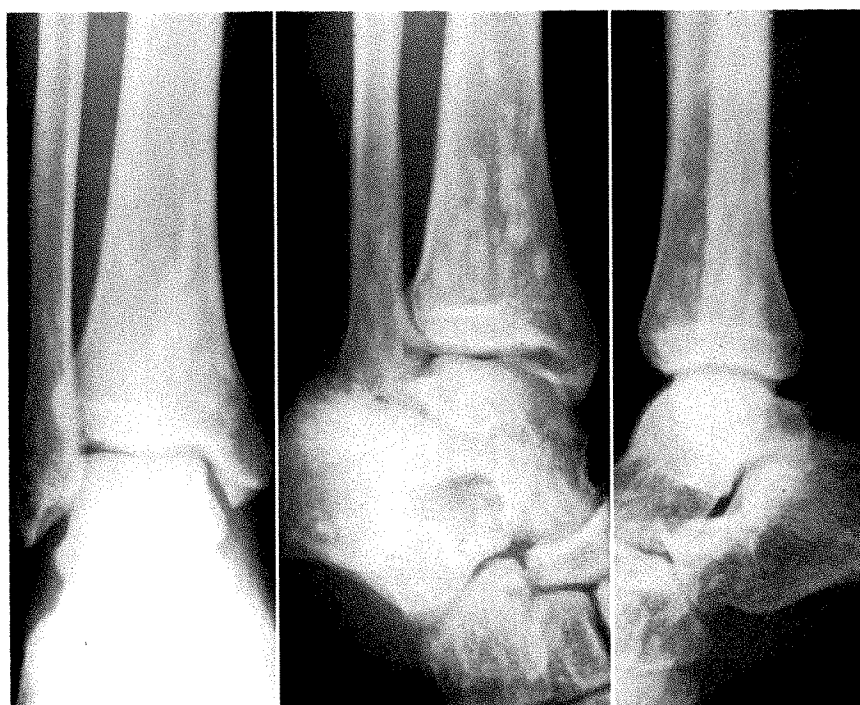


FIG. 10. Osteopoikilosis (Case III). "Spotting" of tibia, fibula and tarsals. Knees also showed typical changes.



FIG. 11. (A and B) Osteopoikilosis (Cases IV and V). Hands and wrists involved. Both cases discovered on roentgenograms ordered because of trauma. (LogEtronic reproduction.)

basis of the predominant lesion. It is interesting to note that most of the cases that show the findings of both diseases have occurred in children or young adults. It is possible that the small sclerotic "spotted" foci may progress to confluent linear hyperostosis as the individual ages.

Table III summarizes the important simi-

larities and differences in the two bone diseases. It can be seen that melorheostosis Leri and osteopoikilosis can occur in either sex at any age. There is no known etiologic factor in either disease, although there is a definite hereditary tendency in osteopoikilosis. The basic pathologic process is a hyperostotic or eburneous focus of bone

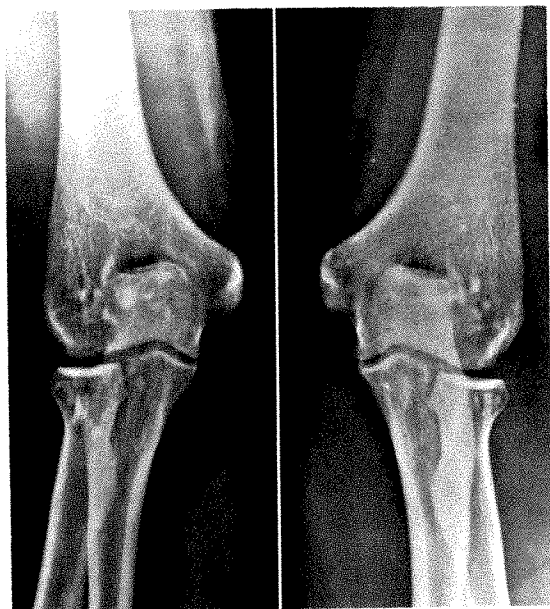


FIG. 12. Osteopoikilosis (Case vi). Elbows showing "symmetric" involvement. (LogEtronic reproduction.)

that may be localized or generalized. The usual histologic pattern of bone is preserved with added proliferation of fibrous tissue. It is doubtful that microscopic differentiation in the two diseases can be made.

The clinical findings in the two diseases are of importance. The majority of persons with osteopoikilosis are asymptomatic and discovered "by chance" on roentgenograms. Many cases have been accompanied by cutaneous manifestations of various descriptions. Most cases that have been followed for years have shown no progress or change in the appearance of the lesions. Melorheostosis Leri, on the other hand, is accompanied by pain, limitation of extremity motion and some debility in the majority of cases. Associated cutaneous or systemic manifestations have occurred infrequently. There has been progression of the bony lesions, including other sites of involvement, in many cases available to follow-up. Several authors report surgical excision or sympathectomy in an attempt to alleviate symptoms.

The sites of occurrence and roentgeno-



FIG. 13. Osteopoikilosis (Case vii). Shoulder involved. Note confluent sclerotic lesion in proximal humeral shaft. Opposite shoulder shows similar involvement. (LogEtronic reproduction.)

graphic findings are different in the two diseases. Osteopoikilosis primarily affects the membranous bones (pelvis, shoulder girdle), ends of long bones, and small bones of the hands and feet. Melorheostosis Leri in most cases shows involvement of the

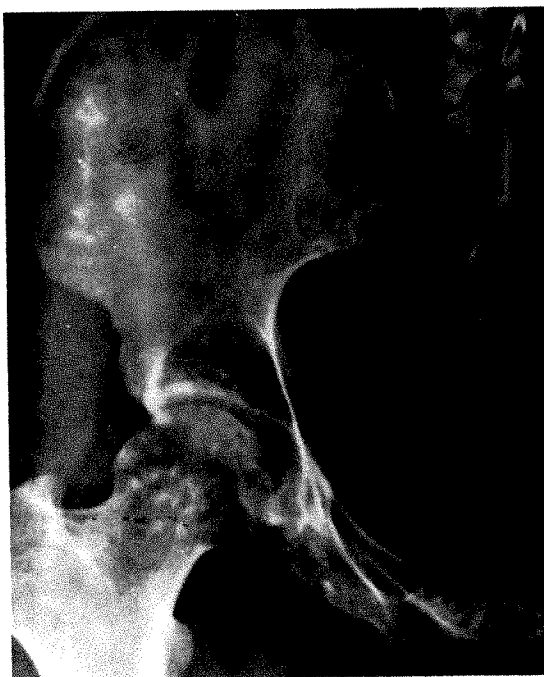


FIG. 14. Osteopoikilosis (Case viii). Small sclerotic foci in hip, ischium, pubis and sacroiliac area. Extensive changes in other skeletal areas. (LogEtronic reproduction.)

long bone shafts, particularly of one side of the bone. The appearance of a flowing, tallow-like hyperostosis and the multiple, small sclerotic "spots" seen on the roentgenograms are usually strikingly different.

REPORTING OF CASES

In the sixty-five years since the discovery of the roentgen ray, many uncommon and unusual entities have been described in the literature. Some are listed under synonyms, associated with varying disorders, and not clearly classified in the general scheme of diseases. Confusion in diagnosis, classification, therapy, and investigative research has been the result. Melorheostosis Leri and osteopoikilosis are two diseases that fall into this category.

We feel that these two diseases are still sufficiently uncommon and that, therefore, all cases should be reported, tabulated and studied. Slightly more than 100 cases of each of these diseases can be counted at the present time. We feel that there are many isolated cases in the roentgenographic and clinical files that have not been reported. We would be interested in reviewing original roentgenograms, photographs, and clinical material for future tabulation. From additional cases, light may be shed on the relationship between the two diseases, definite association with other clinical manifestations, and the general significance of the bone lesions.

SUMMARY

1. A review of the literature and compilation of cases of melorheostosis Leri and osteopoikilosis have been presented. Several of our own cases are reported for the first time.

2. The similarities and differences in these two closely related bone diseases have been discussed.

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ADDENDUM

Two additional cases of probable melorheostosis Leri have been seen at the Santa Rosa Hospital, San Antonio, Texas, by courtesy of Dr. Francis O'Niell. The clavicle was involved in one patient and the pelvis in the second. However, these cases have not been included in the composite summary because of incomplete verification, questionable clinical or roentgenographic findings, or loss of follow-up of the patients.

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OSTEOSCLEROSIS FROM INTENTIONAL INGESTION OF HYDROFLUORIC ACID*

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FLUORIDE osteosclerosis is a rare but not unknown condition with about 100 cases reported in the literature, the largest numbers by Flemming Møller and Gudjonsson,⁶ and Stevenson and Watson.⁸

Industrial exposures to cryolite¹ or crushed phosphate rock⁶ containing sodium fluoride have been proved to produce osteosclerosis. A few years' exposure to fluorine compounds used in the production of glass, aluminum and enamel⁷ and long standing contact with superphosphate fertilizers containing 4 per cent fluorine¹ also produce osteosclerosis. Finally, the drinking for many years of naturally fluorinated water with a content of more than 4 parts of fluorine per million has been shown to produce diffuse bone sclerosis.^{3,5,8,9}

The case reported here is unique in that the osteosclerosis has been produced by intentional ingestion of hydrofluoric acid with bone changes manifested three years after the beginning of the regular ingestion. This represents an almost natural experiment and proves definitely that fluoride produces osteosclerosis.

REPORT OF A CASE

A fifty-two year old candy maker from central Illinois consulted with physicians at the University of Illinois Research and Educational Hospitals in August, 1959, because of an awareness of "dense bones," first noted in an industrial mobile unit chest survey roentgenogram in 1956 and each subsequent year thereafter. He had had no symptoms.

The history revealed that he has been taking four to five drops of a solution of one part of hydrofluoric acid and two parts of water each day since July of 1953, because he believed that it would help his teeth. He also took zinc chloride "to reduce thirst," and hydrochloric acid to "relieve gas." In 1933 he took pancreatin and

insulin in order to gain weight, which he did—from 135 to 180 lb.

The complete physical examination was not noteworthy, except for yellow teeth and an elevated pearly skin lesion, firm in consistency and adjacent to the left earlobe. This lesion was subsequently removed and the microscopic study revealed a basal cell carcinoma.

Serum chloride, phosphorus and phosphatase, sodium, potassium and calcium were within normal limits, as were the postprandial sugar, white blood cell count, hematocrit, differential count and urinalysis.

The roentgenograms he brought with him as well as those we made exhibited abnormally dense bones. The pelvis showed increase in bone density (Fig. 1) without any change in the bony structure *per se*. There was beginning calcification of the pelvic end of the sacrotuberous ligament (Fig. 2). All vertebrae were uniformly dense, without expansion or deformity (Fig. 3

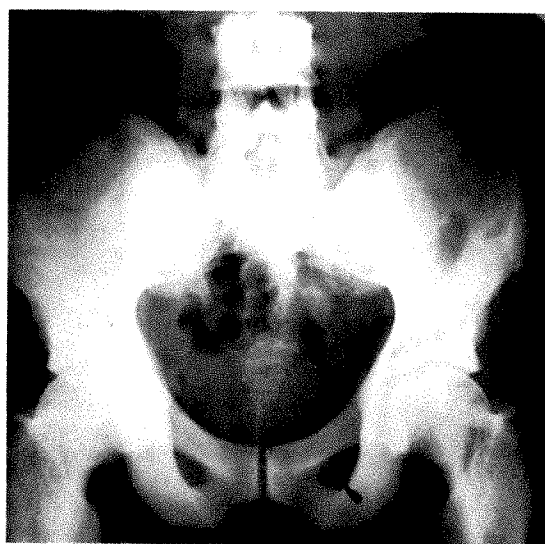


FIG. 1. Anteroposterior roentgenogram of the pelvis showing a generalized increase in bone density without any changes in bone architecture. Note beginning of calcification of the left sacrotuberous ligament (arrow).

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FIG. 2. Beginning calcification of the right sacrotuberous ligament (arrow), typical of fluoride osteosclerosis.

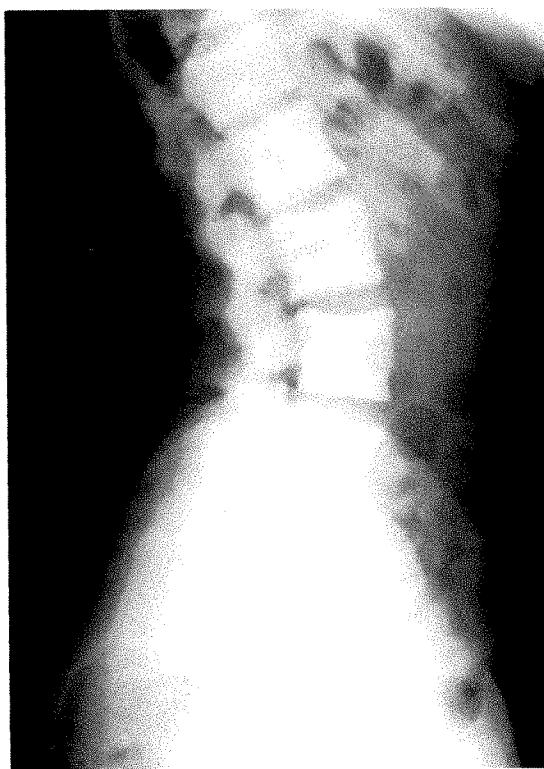


FIG. 3. Lateral roentgenogram of the lumbosacral spine showing eburnation of the vertebrae, which are normal in size and shape.

and 4). All ribs were apparently widened and slightly increased in density (Fig. 4). The skull showed thick and dense bones, especially at the base (Fig. 5); the occipital bone was particularly thick and heavy and the posterior clinoid processes were heavy and dense. The tibiae showed roughening of the periosteum (Fig. 6).

Despite the suggestion that he discontinue the use of the unusual substances he had been taking, the patient seemed disinclined to do so.

DISCUSSION

It has been emphasized in the literature that fluoride sclerosis usually involves the pelvis, spine, ribs, long bones and pelvic ligaments.⁸ In 2 instances, skull involvement has been mentioned^{5,6} with the remark that it is seen in severe and very advanced cases. The case we are reporting can be considered as moderately advanced with almost uniform and symmetric involvement of all the skeleton.

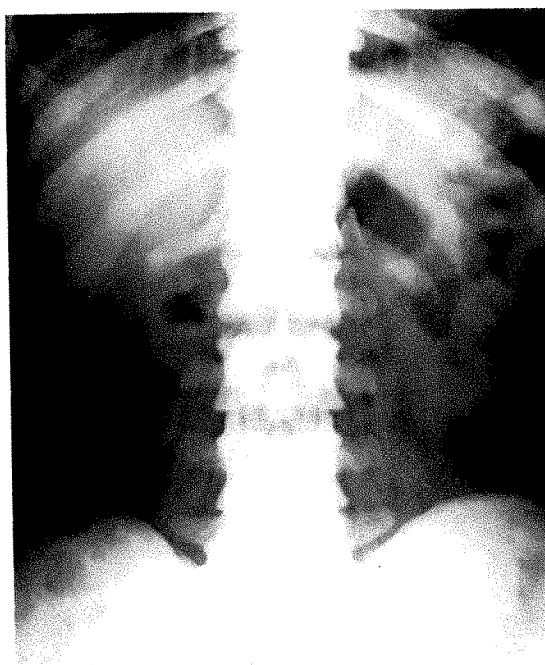


FIG. 4. Anteroposterior roentgenogram of the lower ribs and lumbar spine. Note the widening of all ribs. This is due to calcium fluoride deposits in the soft tissue at the lower costal margins.

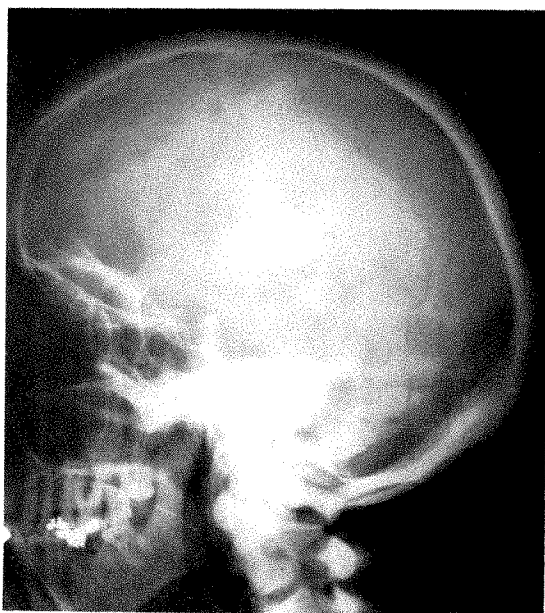


FIG. 5. Lateral roentgenogram of the skull showing thick and dense bones generally and particularly at the base. Note the very heavy posterior clinoids and occipital bone.

The apparent widening of the ribs is due to deposits of calcium fluoride in the soft tissues at the lower margin of the ribs.¹ In general, the normal bone architecture is preserved in fluoride osteosclerosis with only a uniform increase in density, similar to that seen in osteopetrosis. In metastatic bone lesions from carcinoma of the prostate, there are areas of bone absorption around and adjacent to the areas of sclerosis.¹ Calcification of the pelvic ligaments is believed to be present only in fluoride osteosclerosis.⁵

Fluoride penetrates the human body mainly through the alimentary tract.⁴ One-half of the fluoride salts ingested is excreted by the urine and the other half is retained and deposited as calcium fluoride in the skeleton.⁴ Impairment of the kidney function accelerates retention of fluoride in the body and may accentuate generalized effects.⁵

Individuals with fluoride osteosclerosis are usually asymptomatic;⁸ however, cases have been reported with secondary anemia

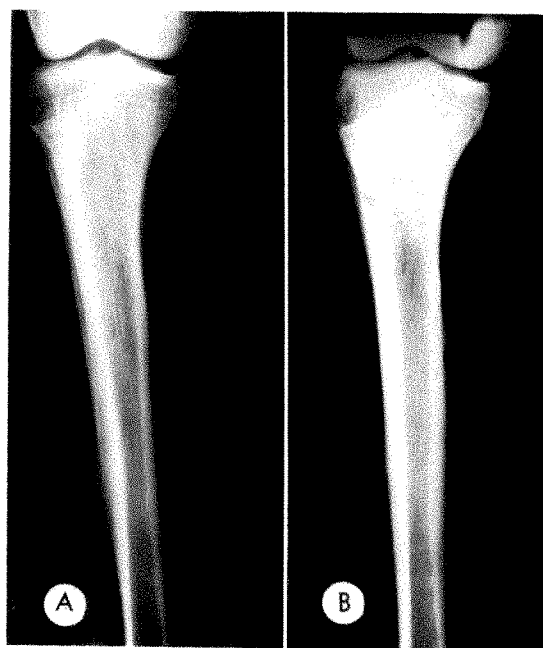


FIG. 6. (A and B) Anteroposterior and oblique roentgenograms of the leg showing roughening of the periosteum of the tibia, very typical in fluoride sclerosis.

due to myelosclerosis following the osteosclerosis² or with advanced vertebral sclerosis with resulting compression of the spinal cord with paraplegia.⁹ Simultaneously occurring silicosis from aspiration of cryolite dust has also been reported.³

SUMMARY

A case of moderately advanced fluoride osteosclerosis from intentional and regular ingestion of hydrofluoric acid is reported. Contrary to the generally accepted belief, the skull may be involved in the early stages of fluoride osteosclerosis, especially when intake is high.

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GONADAL DYSGENESIS

CLINICAL AND ROENTGENOLOGIC MANIFESTATIONS

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THE discovery of the syndrome of gonadal dysgenesis is generally credited to Turner³⁵ who in 1938 reported 7 cases of young women with infantilism, congenital webbed neck, and cubitus valgus. Since then there have been numerous cases with this syndrome reported, many with a variety of congenital defects supplementing or modifying the originally described triad. Various authors have attached different terms to the syndrome so that the literature is replete with names which may well serve to confuse the reader. These include Turner's syndrome, Varney-Turner syndrome, Bonnevie-Ullrich syndrome, webbing syndrome of Ullrich-Turner, Albright's syndrome, ovarian agenesis, ovarian dysgenesis, syndrome of rudimentary ovaries, congenitally aplastic ovaries, gonadal agenesis, and gonadal dysgenesis.^{14,29,38} ("Turner's syndrome" is an eponym also given to the syndrome of hypoplasia of the patella and thumbnails.^{27,36})

Currently, it is felt that the term "gonadal dysgenesis" should be applied to the disorder in its many forms.¹⁵ Classically, the syndrome presents as (1) short stature, most patients being between 4'6" and 4'10" in height, (2) sexual infantilism, (3) primary amenorrhea, and (4) a wide variety of congenital anomalies.^{17,21} Of the latter the more common ones are webbing of the neck, short phalanges of the hands or feet, cubitus valgus (exaggerated carrying angle), wide arm span, medial tibial condyle defects, osteoporosis, slight delay in bone maturation, coarctation of the aorta, shield-shaped chest, and low hairline. The less frequent anomalies include fused cervical vertebrae, scoliosis, spina bifida occulta, visual defects, deafness of varying degree, high arched palate, low placed

ears, hypoplasia of the mandible, mongoloid features, syndactylism, Madelung's deformity, pes cavus, blue sclerae, hypertension of unknown cause, renal anomalies, mental retardation, lymphangiectatic edema, especially of the dorsum of the hands, telangiectases, and pigmented nevi. Anomalies affecting almost every organ of the body have been described. There have also been cases of proved gonadal dysgenesis without obvious congenital abnormalities.²¹

The syndrome is accompanied by high urinary gonadotropin titers and decreased urinary estrogen and 17-ketosteroid excretion. Exceptions to the classic chemical findings have been reported.²²

Gonadal dysgenesis is generally considered to be nonfamilial and nonhereditary though a genetic theory has been proposed to account for it and its variants.²¹ Grumbach and Barr,¹⁶ in their review, were able to find only 8 families in which more than one individual was affected. There has been one report of occurrence in both of an identical twin pair²⁸ and one report of occurrence in 3 sisters.⁷

Gonadal dysgenesis has also been reported in a number of males.^{4,16,18,31} Short stature was present in all and webbed neck and cubitus valgus were the most common associated skeletal defects. One or both testes were present. In almost all cases the testes were underdeveloped.

In persons with gonadal dysgenesis, the uterus is infantile and the gonads are rudimentary, lacking gametogenic parenchyma. The gonads are whitish streaks within the broad ligament composed of wavy connective tissue, varying numbers of Leydig cells, and vestigial glandular structures of the rete ovarii in the hilus.¹²

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since they do contain mesonephric remnants, they do not represent true agenesis, affirming that "dysgenesis" is a more appropriate term.

There have been case reports of tall, eunuchoidal patients with gonadal dysgenesis.^{7,14,21,26,39} Consideration of these cases supports the view that the shortness of stature generally found is genetic in origin.^{1,20,26} Further evidence of this is the increased amount of growth hormone found in patients with gonadal dysgenesis who have short stature.¹⁰ In addition, there have been rare cases of gonadal dysgenesis with androgenic manifestations; virilization, clitoral hypertrophy, hirsutism, and android pelvis.¹¹

The great majority of females with gonadal dysgenesis have male chromatin patterns but may not necessarily be genetic males. This can best be proved by study of the intracellular chromatin pattern. Barr, Bertram and their co-workers^{5,6} discovered that the chromatin pattern of males was different from that of females regardless of the tissues studied. In normal females there is condensation of the nuclear chromatin, typically a planoconvex mass, in the periphery of the nucleus, known as the "positive chromatin" pattern (Fig. 1). Absence of the chromatin clump is known as the male or negative chromatin pattern. In normal females over 40 per cent of the cells have the chromatin clump, while in normal males 0 to 6 per cent of the cells have this chromatin pattern.^{13,32} Eighty to 90 per cent of all females with gonadal dysgenesis have a negative chromatin pattern.^{32,33} These patients believe themselves to be females.^{2,19} In a psychologic study of a group of girls and women with gonadal dysgenesis, Hampson *et al.*¹⁹ found all the patients "unequivocally to fulfill the cultural and psychological expectations of femininity."

One theory as to etiology is that the anomalies are a result of injury to certain regions or metabolic processes of the embryo at some critical stage. This might result from a maternal virus infection, hormonal imbalance, or other adverse condi-

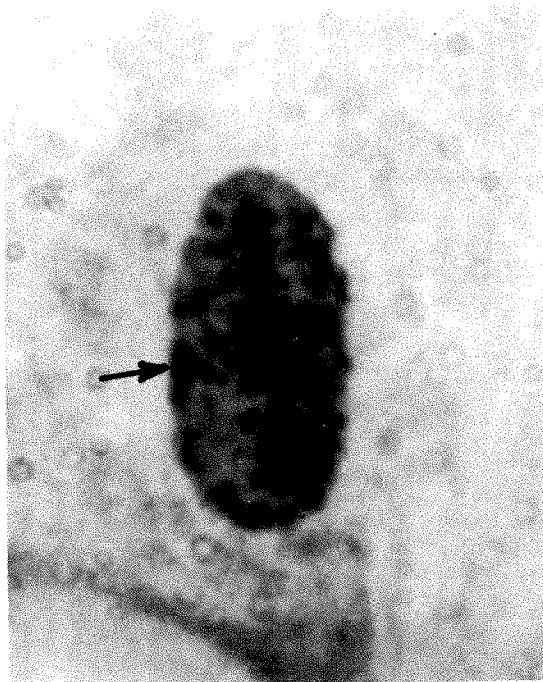


FIG. 1. Photomicrograph showing planoconvex chromatin mass in the periphery of the nucleus (arrow). Buccal smear, $\times 3,200$, Biebrich Scarlet and Fast Green stain.

tion. Another theory offered is injury to the genes of the ovum, sperm, or zygote. "The strange spectrum of seemingly unrelated coexisting anomalies might indicate a juxtaposition of potential organizing factors, such as is found in the arrangement of the genes in chromosomes."²⁸ Hoffenberg and Jackson²⁰ postulate three closely connected genes situated on the same chromosome, one for infantilism, one for stature, and the third gene or gene complex for the various anomalies of the musculoskeletal, cardiac, cutaneous, renal, ocular, and other systems. The third gene or gene complex is evidently variable in its expressivity since several different anomalies may occur together but all possible anomalies do not occur in the same individual. Recent studies on chromosomal patterns have shown that the majority of females with Turner's syndrome have only one sex chromosome; that is, they have an XO pattern instead of the normal XX pattern.^{8,9} (The development of the gonadal cortex

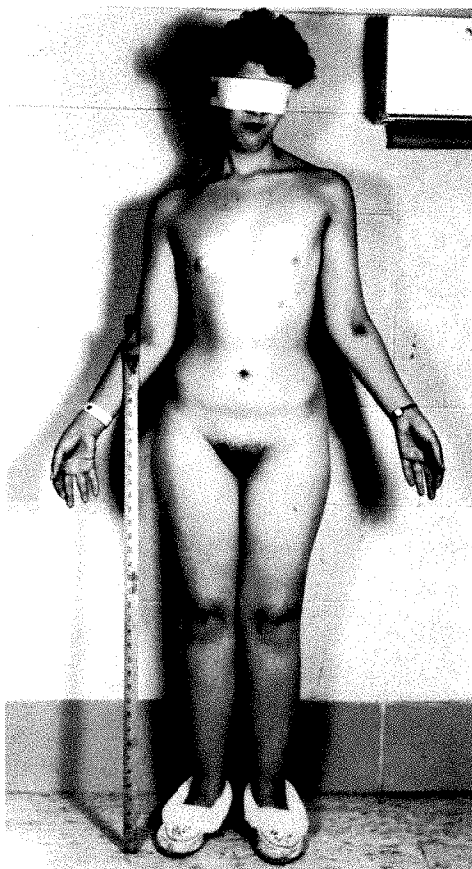


FIG. 2. Case I. Photograph showing gonadal dysgenesis. Female, 21 years old. Note the short stature, "shield-like" chest, absent breast development, cubitus valgus, neck webbing, and sparse pubic hair.

[ovarian precursor] depends upon the presence of two X chromosomes and that of the gonadal medulla [testicular precursor] upon a Y chromosome; thus Turner's syndrome is considered an example of cortical gonadal dysgenesis.²⁴⁾

As would be expected in a condition having such widespread organ involvement, the roentgenologic findings are many. Some are well-nigh pathognomonic, while others are quite nonspecific. The description of some cases will serve to demonstrate most of the more common findings reported in cases with gonadal dysgenesis.

REPORT OF CASES

CASE I. E.S. This twenty-one year old white female had never menstruated and had no de-

velopment of secondary sex characteristics (Fig. 2). The breasts were immature, the uterus was infantile by rectal examination, there was no axillary hair, and the pubic hair was sparse. She was 58 inches tall and weighed 108 pounds. Her intellect was normal. Her heart sounds and blood pressure were normal. There were moderate cubitus valgus and short fourth metacarpals. Neck webbing was equivocally present. There was no auditory or visual difficulty. The urinary 17-ketosteroids were decreased and the gonadotropins increased. A vaginal smear showed no estrogenic effect. Scrapings of the buccal mucosa revealed a negative chromatin pattern.

Roentgenographic findings: Generalized bone demineralization; slightly delayed ossification (ununited iliac crest epiphyses); short fourth metacarpals (positive metacarpal sign); deformity of medial femoral and tibial condyles (positive knee sign); scoliosis; cubitus valgus; infantile uterus and absent ovaries; and azygos fissure.

CASE II. P.S. This twenty-one year old white female entered the hospital because of anemia, gingival bleeding, and skin ecchymoses. She had primary amenorrhea, lack of breast development, and absence of pubic and axillary hair. At the age of seventeen years she was placed on cyclic stilbestrol therapy resulting in breast development, hair growth, and regular, scanty menses. She was 56 inches tall and weighed 90 pounds. The blood pressure and heart sounds were normal. Her carrying angle was exaggerated bilaterally and the fifth metacarpals were short. There was moderate neck webbing. She was of normal intelligence. No pelvic organs could be palpated. The urinary 17-ketosteroids were decreased and the gonadotropins only minimally increased; it was felt that the latter were depressed by the stilbestrol. Buccal scraping revealed a negative chromatin pattern. The anemia was thought to be due to bone marrow depression caused by the estrogen therapy but there was no improvement when the therapy was discontinued.

Roentgenographic findings: Generalized bone demineralization; slightly delayed ossification (ununited iliac crest epiphyses); short fifth metacarpals; positive knee sign; scoliosis; absent ovaries; bilateral renal malrotation; and "benign cortical defect" of right femur.

CASE III. P.L. This twenty-three year old

Negro female was 56 inches tall and weighed 105 pounds. She had primary amenorrhea, absent breast development, and sparse axillary and pubic hair. She had had a marked strabismus which was corrected surgically at ten years of age. Her palate was distinctly higher than normal and was arched. There was no hearing difficulty. The neck was webbed and the hairline low. The carrying angle was normal. The fourth fingers were unusually short. Her span exceeded her height by two inches. The labia were underdeveloped; the uterus felt smaller than normal and neither ovary could be palpated. The blood pressure and heart sounds were normal. She was of normal intelligence. The urinary 17-ketosteroids were below normal and the gonadotropins elevated. A buccal smear revealed a negative chromatin pattern.

At the age of sixteen years she had been placed on stilbestrol therapy resulting in regular menstrual periods and moderate breast development. After a few years she voluntarily stopped taking estrogens. The menses ceased; the breast enlargement persisted.

Roentgenographic findings: Generalized bone demineralization; slightly delayed ossification (united iliac crest epiphyses); scoliosis; infantile uterus and absent ovaries; and expanded left third rib.

CASE IV. N.L. This seventeen year old Negro female was 54 inches tall. She had primary amenorrhea, no breast development, and absence of axillary and pubic hair. Her left ear was abnormally large. The carrying angle was somewhat exaggerated. There was no neck webbing. The blood pressure on occasion was found to be elevated to approximately 150 mm. Hg systolic and 110 mm. diastolic; at other times it was normal. There was no cardiomegaly and no murmur; the femoral pulses were normal. The fourth fingers were short and the left fourth toe small and deformed. There was no evident impairment of intellect. The external genitalia were infantile in appearance. Neither the uterus nor the adnexa could be palpated. The urinary gonadotropins were appreciably elevated and the 17-ketosteroids decreased. A negative chromatin pattern was found on study of the buccal mucosa.

Roentgenographic findings: Generalized bone demineralization; slightly delayed ossification (iliac crest epiphyses not ossified, lesser trochanter ununited); positive metacarpal sign;

positive knee sign; scoliosis; cubitus valgus; infantile uterus and absent ovaries; short left fourth metatarsal and 13 ribs bilaterally.

CASE V. C.P. This patient, a twenty year old white female, had never menstruated, had no breast development, and had scanty pubic and axillary hair until treated with estrogens at the age of sixteen years. With this treatment she menstruated regularly, her breasts developed, and the pubic and axillary hair increased in amount. The patient was 52 inches tall; her span was 54 inches. There was slight neck webbing, the hairline was low, the palate was high and arched, cubitus valgus was present, and there were large flat hemangiomas over the right side of the neck, left face, and left side of the nose. The fourth metacarpals were short. The blood pressure and heart size were normal. There was a Grade I systolic murmur over the cardiac apex. The external genitalia were infantile. The uterus felt small and the adnexa could not be palpated. The patient seemed to be of normal intelligence. A buccal smear revealed a negative chromatin pattern.

Roentgenographic findings: Generalized bone demineralization; slightly delayed ossification (united iliac crest epiphyses); positive metacarpal sign; positive knee sign; cubitus valgus; infantile uterus and absent ovaries.

CASE VI. E.N. This white female was first seen in Michael Reese Hospital when she was forty-one years old. She was admitted to the hospital because of anemia. She presented the typical history of ovarian dysgenesis: short stature (54 inches), primary amenorrhea, absent breast development, absent axillary and scant pubic hair, infantile external genitalia, and short fourth metacarpals. In addition, she had a moderate kyphoscoliosis and pigeon chest deformity. There was no neck webbing or cubitus valgus. The blood pressure was normal. The urinary gonadotropins were moderately elevated. A buccal smear disclosed a negative chromatin pattern.

Roentgenographic findings: Generalized bone demineralization; positive metacarpal sign; positive knee sign; scoliosis; infantile uterus and absent ovaries; and renal malrotation.

Comment. At the time of this writing, 3 of the 6 patients have been followed on cyclic estrogen therapy. Each responded with breast enlargement, establishment of



FIG. 3. Case 1. Roentgenogram showing exaggeration of the carrying angle. This was also present in Cases II, IV, and V.

cyclic vaginal bleeding, and growth of pubic and axillary hair. Since hair growth has been considered an adrenal androgen effect, the growth of pubic and axillary hair in response to estrogen therapy would appear unexpected. It is considered that this response in persons with gonadal dysgenesis is due to pituitary stimulation and consequent increased adrenal activity.^{1,39}

ROENTGENOGRAPHIC FINDINGS

Reproduction of all the positive roentgenographic findings in the reported cases would make for needless repetition. Thus, for the most part only examples are shown (Fig. 3-7; and 9). However, because of their importance as diagnostic signs, their frequency of occurrence, and heretofore lack of mention in the radiologic literature, the positive metacarpal (Fig. 8, A-F) and knee (Fig. 10, A-F) signs are shown for each case.

The changes found on the roentgenograms of the knees were noted by Kosowicz²⁵ who in 1959 reported that the deformity of the medial tibial condyle was present in 12 of 18 cases of Turner's syndrome studied. These were in patients aged eight to forty-two years. As in the cases herein reported, clinical examination did not reveal any lateral bowing of the tibia or any knee deformity. Kosowicz referred to these changes as resembling Blount's disease roentgenographically though not bearing any clinical similarity. The knee changes are bilateral and generally symmetrical. The medial femoral condyle is larger than the lateral and extends downward below the level of the lateral condyle. The medial tibial condyle is enlarged and projects medially. In some instances a beak-like exostosis projects from the medial tibial condyle. The tibial epiphyseal plate is angled obliquely medially and downward. The proximal tibial epiphysis is likewise deformed; its medial aspect spreads pointedly toward the enlarged and depressed metaphysis. Kosowicz noted that in some cases an accessory ossification center arises separately on the medial aspect but soon fuses with the epiphysis. It is of interest that Perloff and Stein³⁰ in 1953 reported a case of gonadal dysgenesis and described deep femoral condyles with correspondingly deep tibial grooves for the condyles.

The matter of metacarpal shortening in gonadal dysgenesis is an interesting one and has been the subject of careful study by Archibald, Finby and De Vito.³ These investigators studied the hands, clinically and roentgenographically, of 2,594 patients. Their findings indicate that shortness of the fourth metacarpal relative to the third and especially relative to the fifth is of frequent occurrence in patients with gonadal dysgenesis having either female or male sex chromatin. Normally, a line drawn tangential to the distal end of the heads of the fifth and fourth metacarpals extends distal to the third metacarpal. A positive metacarpal sign is present when

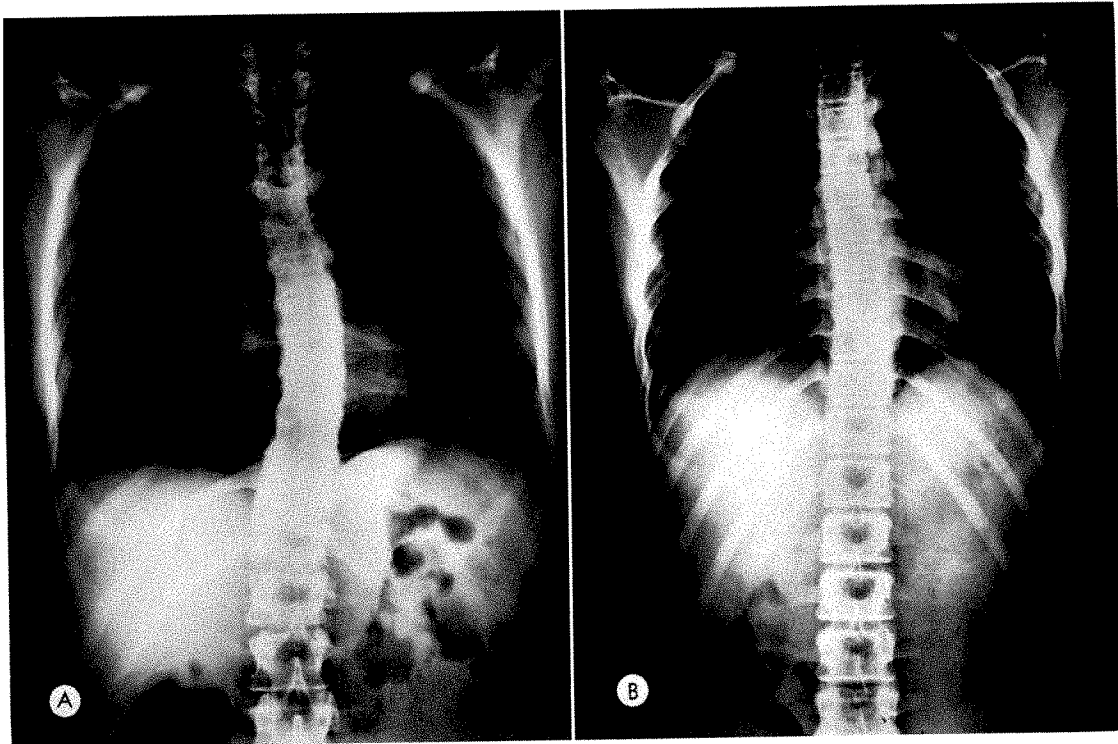


FIG. 4. (A) Case II. Moderate degree of thoracic spine scoliosis. Scoliosis was also present in Cases I, III, IV and VI. (B) Case IV. Scoliosis. There are 13 ribs bilaterally.

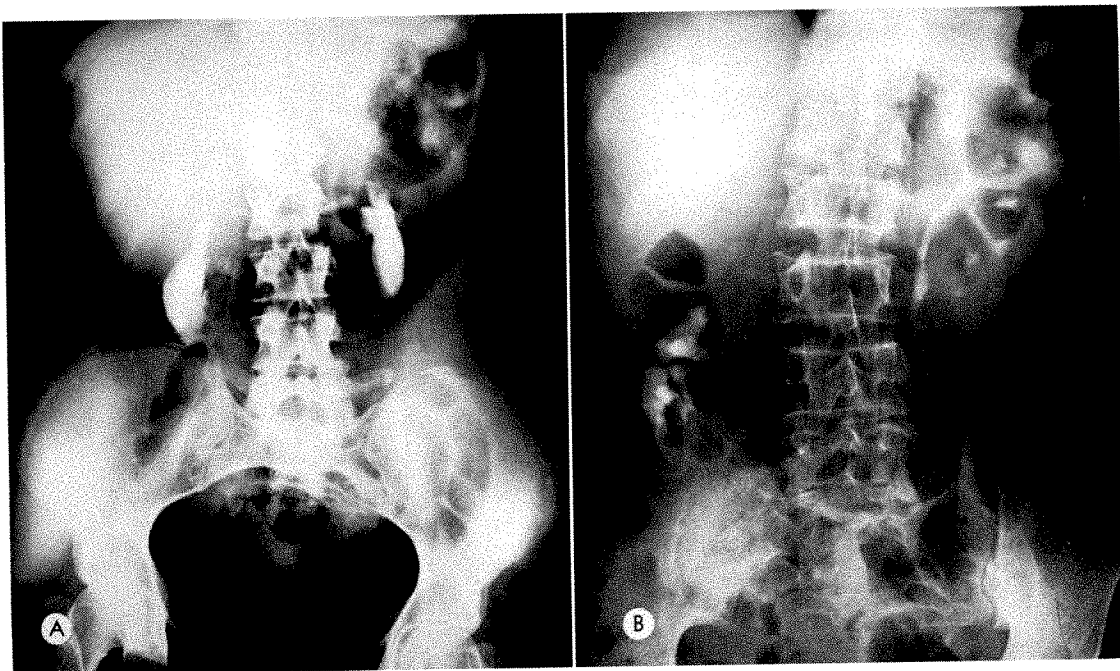


FIG. 5. (A) Case II and (B) Case VI. Aberration of renal rotation.

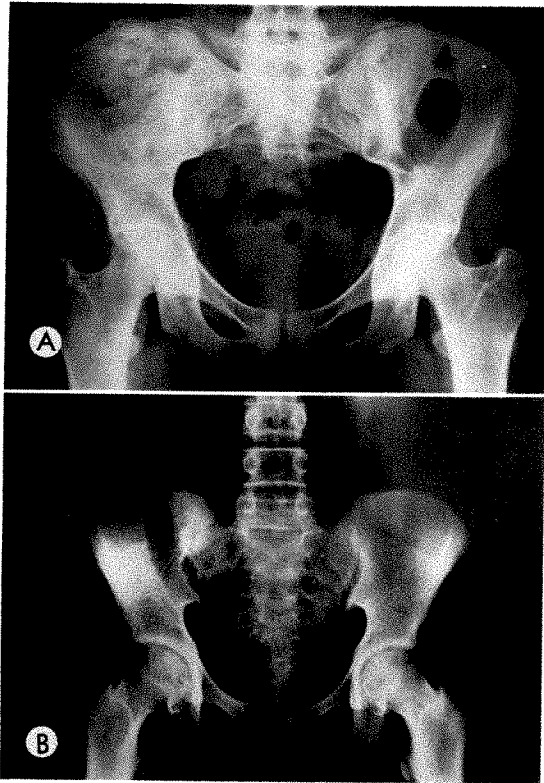


FIG. 6. (A) Case I. Female, 21 years old. Iliac crest epiphyses are not fused. (B) Case IV. Female, 17 years old. Iliac crest epiphyses are as yet not ossified. Lesser trochanter epiphyses are ununited.

←

tial to the head of the third metacarpal, the sign is considered a borderline one.

Of 17 female patients with gonadal dysgenesis, 11 had a positive metacarpal sign and 3 had a borderline sign. The positive sign is most often bilateral. The left side is the one of most frequent occurrence and degree of positiveness; this is apparently not related to hand dominance. One patient had very short fifth metacarpals, similar to Case II. In males the metacarpal sign was frequently associated with testicular atrophy, delayed sexual maturation, or delayed testicular descent. However, none of 5 cases of Klinefelter's syndrome (testicular dysgenesis), all with female sex chromatin, had either a positive or borderline metacarpal sign.

These investigators also conclude that the metacarpal sign is without significance as far as gonadal development is concerned

the line passes through the head of the third metacarpal. When the line is tangen-

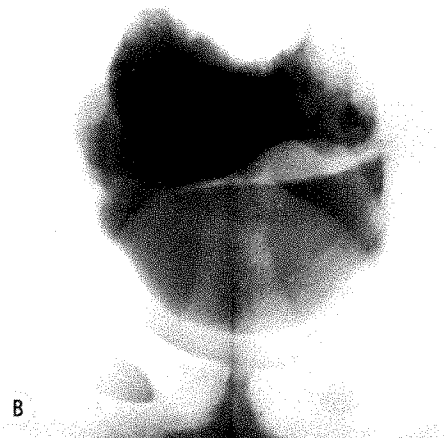


FIG. 7. Pelvic pneumograms. (A) Case II. No ovary is present. The uterus is near-normal size, perhaps as a result of estrogen therapy. (B) Case IV. The uterus is infantile. No ovary is present. The pelvic pneumograms of Cases I, III, V, and VI were similar to this one.

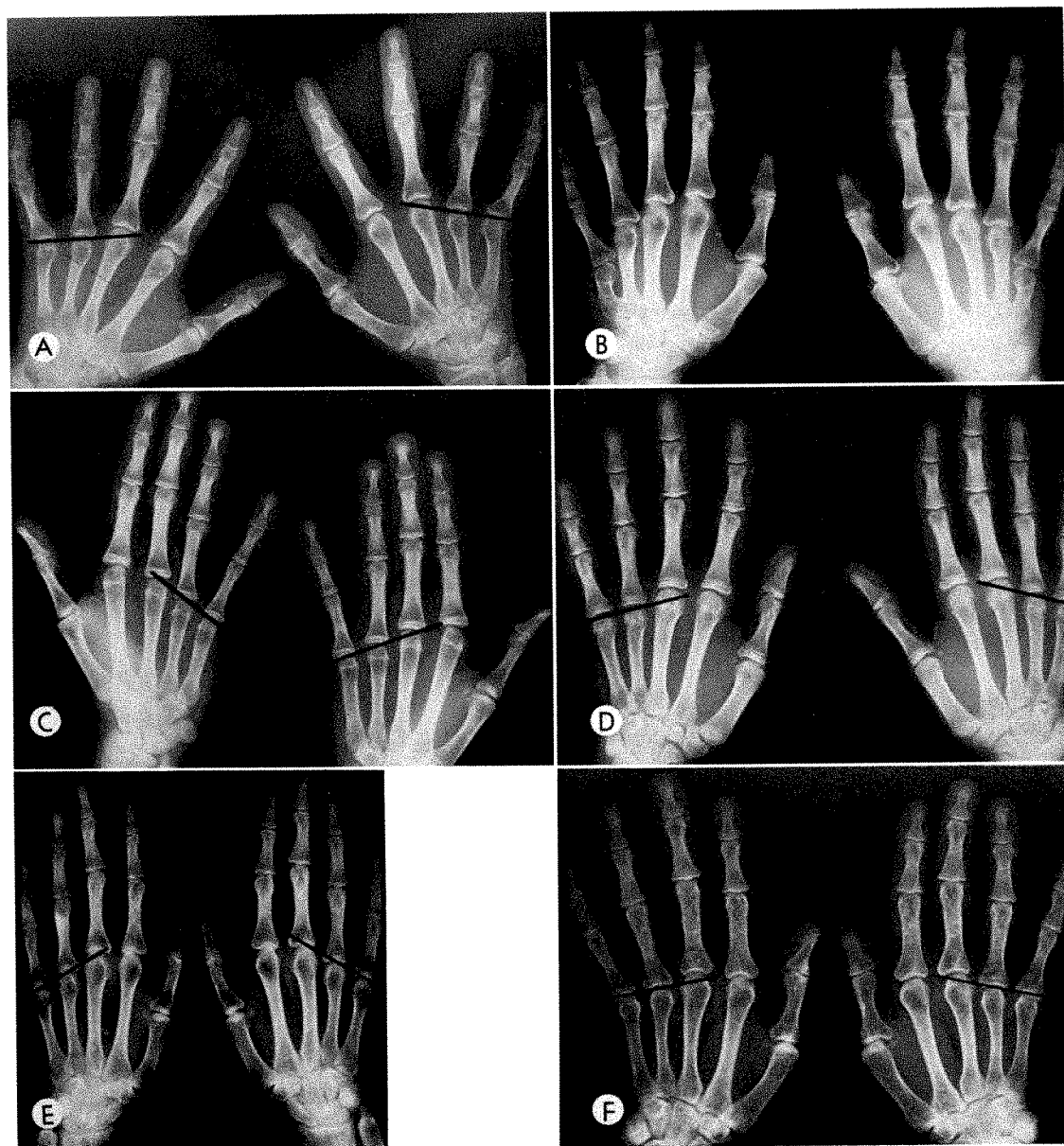


FIG. 8. (A) Case I, (B) Case II, (C) Case III, (D) Case IV, (E) Case V, and (F) Case VI. A positive metacarpal sign is present in all cases, modified in Case II by unusually short fifth metacarpals.

when found in more than one generation of the same family. When found in only one generation, the sign is frequently associated with gonadal anomaly. Also, patients having a metacarpal sign usually have delayed skeletal maturation. Because of the many other skeletal and congenital anomalies found in patients with gonadal dysgenesis, the authors conclude that the met-

acarpal sign is merely another skeletal anomaly.

Bone demineralization is a common accompaniment of ovarian dysgenesis. This can be attributed to the lack of estrogen, analogous to postmenopausal osteoporosis (and probably to androgen deficiency as well).

Many authors have stressed the fre-

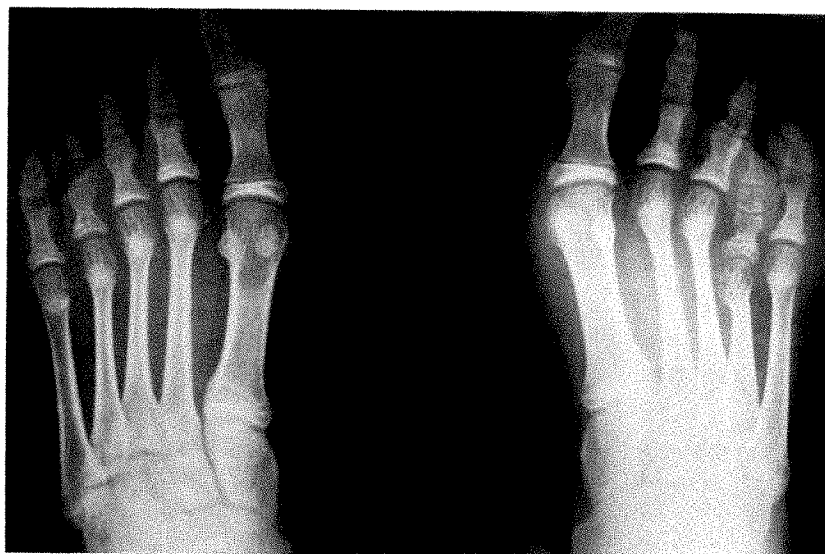


FIG. 9. Case IV. The left fourth metatarsal is far shorter than normal.

quency of cubitus valgus in their patients with gonadal dysgenesis. Hoffenberg and Jackson,²¹ however, found only one patient with cubitus valgus in their series of 27 patients; the valgus deformity was minimal at that. These authors question whether this anomaly really exists in the gonadal dysgenesis syndrome. Further, they note that very minor flexion of the elbow joint allows considerable abduction of the forearm which can closely simulate cubitus

valgus in photographs. The present author feels that Cases I, II, IV and V presented true cubitus valgus, the carrying angle being less than 160 degrees.

Pelvic pneumoperitoneum studies augment the clinical findings and biochemical assays in making the diagnosis of gonadal dysgenesis. In none of the cases of this series could ovaries be identified. In some, a urogenital ridge could be made out. The uterus is usually infantile in size. In one

TABLE I
SUMMARY OF CLINICAL AND ROENTGENOLOGIC FINDINGS

Case	Age	Height	Webbing	Cubitus Valgus	Scoliosis	Blood Pressure	Ossification Delay	Metacarpal Sign	Knee Sign	Deminerization	Renal Malrotation	Chromatin Pattern	Miscellany
I	21	58"	+	+	+	Normal	+	+	+	+	*	Male	Azygos lobe
II	21	56"	+	+	+	Normal	+	+	+	+	+	Male	"Benign cortical defect" of femur. Aplastic anemia. Short 5th metacarpals
III	23	56"	+	o	+	Normal	+	+	+	+	*	Male	Expansion of left third rib. Strabismus. High arched palate
IV	17	54"	o	+	+	Elevated	+	+	+	+	o	Male	Short 4th metatarsal, 13 ribs bilaterally. Large left ear
V	20	52"	+	+	o	Normal	+	+	+	+	*	Male	Skin hemangiomas. High arched palate
VI	41	54"	o	o	+	Normal	o	+	+	+	+	Male	"Pigeon breast"

* No urographic study.



FIG. 10. (A) Case I, (B) Case II, (C) Case III, (D) Case IV, (E) Case V, and (F) Case VI. Positive knee signs are present in all cases. Tibial spurs are present in Cases I and II (arrows); tibial beaking is prominent in Cases III, IV, V, and VI. The medial femoral condyle is prominent in each case as is downward and medial angulation of the medial articulating surface. Case II also has what appears to be a benign cortical defect of the right femur.

case (Case II) in which the uterus appeared to be of near-normal size, the patient had received estrogens for some years prior to the examination; this could well have influenced the size of the uterus.

Aberrations of renal rotation have been reported as one of the more common anomalies in gonadal dysgenesis.²³ It is interest-

ing that in this small series 2 of the 3 patients who had roentgenologic studies of the urinary tract were found to have abnormally rotated kidneys.

There are differences of opinion in the literature as to whether or not there is delayed osseous maturation accompanying gonadal dysgenesis. Many reports do make

direct reference to delayed epiphyseal closure in male and female patients. Lissner *et al.*²⁶ noted that "Retardation of epiphyseal closure is not the usual finding in this syndrome, which is surprising in view of the striking genital infantilism." Further, Tanner *et al.*³⁴ concluded that "... though in Turner's syndrome there is probably some slight retardation compared with the girls' standards, together with abnormal asymmetry of development, in general XO leads to approximately the same skeletal age as XX." The writer feels that delay in iliac crest epiphyseal closure in Cases I, II, III, and V, ages twenty-one, twenty-one, twenty-three, and twenty years, respectively, and absence of ossification in the crest epiphyses in Case IV, a seventeen year old Negro female, does represent at least slight delay in epiphyseal closure.

Though none of the cases in this series had coarctation of the aorta, it should be noted that this is one of the more common anomalies associated with gonadal dysgenesis in females. Coarctation of the aorta is relatively uncommon in females as compared with its occurrence in males, and, when it is found, one should give consideration to the possibility of coexisting gonadal dysgenesis.³⁷

The compilation of the clinical and roentgenologic findings in the reported cases is given in Table I.

SUMMARY

Gonadal dysgenesis is a defect of reproductive organs with many resultant biochemical abnormalities and associated anatomic anomalies. The diagnosis can be suspected from the spectrum of clinical appearances and confirmed, in most instances, by study of the somatic tissue nuclear chromatin distribution. A male chromatin pattern is found in about 80 per cent of females with gonadal dysgenesis.

The case histories of 6 patients with gonadal dysgenesis are presented together with the roentgenographic findings. Many

of the latter are nonspecific but two are near-pathognomonic in suspect cases. These are abnormally short fourth metacarpals and deformity of the medial femoral and tibial condyles.

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ROENTGEN FINDINGS IN ABNORMAL DEPOSITION OF CALCIUM IN TISSUES*

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RADIOLOGISTS are not infrequently confronted with roentgenograms revealing abnormal calcium deposits in the soft tissues. In the majority of cases, the explanation is readily apparent and the calcification is often accepted as an incidental finding, as in the arteriosclerosis of old age. On occasion, however, the calcification, previously unencountered, is bizarre, and requires considerable study to determine its etiology. The chance observation of 3 cases in the latter category during a period of one week within our X-ray Department stimulated the preparation of this paper.

A rather extensive review of the literature on the subject of soft tissue calcification soon led to the realization that hundreds of disease processes may lead to abnormal calcium deposition. Obviously, it is impossible to cover a topic of this magnitude within a reasonable time limitation; consequently, this presentation will deal with the more exotic conditions, those presenting differential diagnostic problems and those which may be first diagnosed by the radiologist.

In general, abnormal calcification may be divided into 6 main categories; namely, (1) metastatic calcification, (2) calcinosis, (3) dystrophic calcification, (4) heterotopic bone formation, (5) vascular calcification, and (6) stone formation. For the sake of continuity, each of these categories will be discussed briefly, with examples and case reports given.

METASTATIC CALCIFICATION

Calcification of a metastatic type occurs primarily in areas with an increased alkalinity, which favors the deposition of calcium in the form of calcium phosphate.

The relationship of destructive bone disease to metastatic calcification was recognized as early as 1855 by Virchow.¹⁶ It has since been shown histologically that the kidneys, especially the renal tubules, the stomach, primarily the gastric mucosa adjacent to acid-secreting glands, and the lungs, chiefly the alveolar walls and vessels, serve as the most frequent sites of metastatic calcification. There are 4 conditions that tend to favor this phenomenon: (1) an increase in the concentration of ionized calcium in the serum, (2) a localized increase in alkalinity, (3) an increase in serum phosphorus, and (4) a generalized increase in alkalinity. Disease processes frequently associated with metastatic calcification include hyperparathyroidism, renal failure, hypervitaminosis D, and lesions resulting in widespread bone destruction such as leukemia, myeloma, and extensive metastatic bone disease.

ILLUSTRATIVE CASES

CASE 1. This seven year old white female was admitted to the hospital with a history of diarrhea and irritability with onset at the age of ten months. A parathyroid exploration was negative. Serum calcium values ranged from 11 to 14 mg. per cent. The patient was subsequently placed on cortisone and a low calcium diet and since has done well.

Roentgenograms demonstrated extensive calcification of the tentorium and falx (Fig. 1A) as well as progressive calcification of the pancreas and kidneys (Fig. 1B).

Comment. Extensive studies failed to account for the elevated serum calcium. The diagnosis, therefore, has been carried over as idiopathic hypercalcemia. The calcification changes were classified as metastatic calcification due to continued hypercalcemia.

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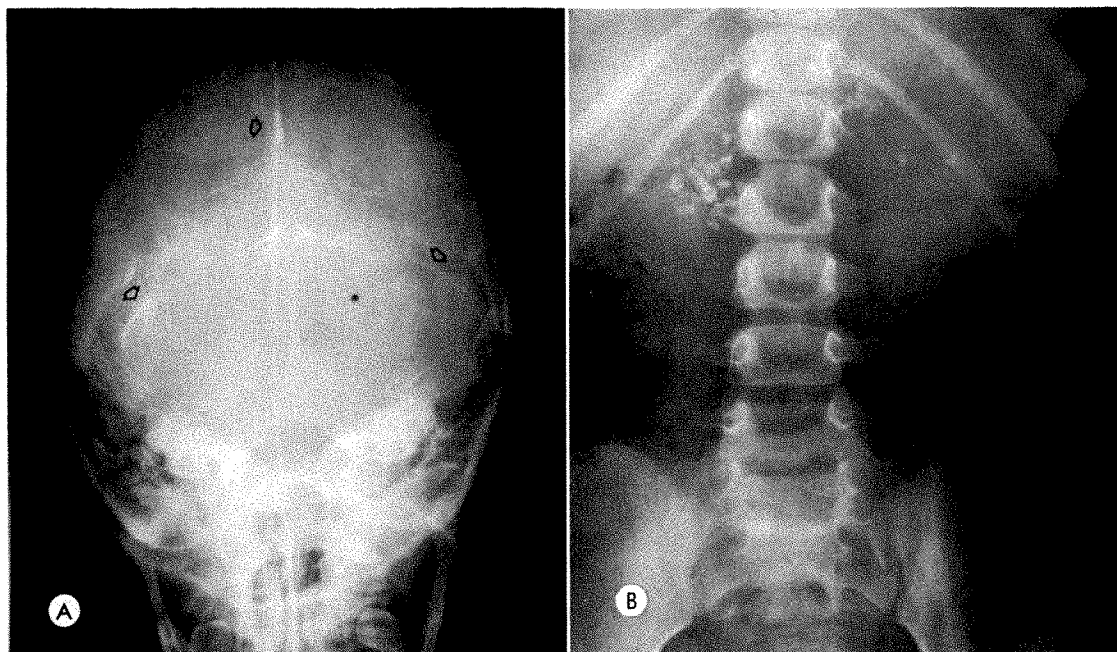


FIG. 1. Case I. Idiopathic hypercalciuria. (A) Extensive metastatic calcification in falx and tentorium (arrows). (B) Progressive calcification of kidneys and pancreas.

Widespread calcification of the tentorium and falx is most unusual for a child of this age group. Likewise, a combination of renal calcinosis and pancreatic calcification in a seven year old patient is indeed rare.

CASE II. This fifty-two year old white female was admitted to the Clinical Center with a four year history of weakness and lethargy. Previous hospitalization elsewhere had resulted in a diagnosis of hyperparathyroidism. Surgical exploration for parathyroid pathology at that time was nonrevealing.

On this admission, a parathyroid exploration was scheduled but not performed since the patient spontaneously fractured both hips while lying in bed. Hip nailing on the right was performed but the patient developed a post-operative pneumonia and died two days later. At autopsy a large parathyroid adenoma was found in the left sternoclavicular region.

Roentgenograms showed the typical findings of advanced hyperparathyroidism. There was marked demineralization of the bony structures associated with metastatic para-articular calcification (Fig. 2A). Other findings consisted of loss of lamina dura, fraying of the lateral ends of the clavicles and collapse of numerous bony structures.

Comment. Metastatic calcification tends to occur in the stomach, lungs, and kidneys. Subradiologic calcification was present in the kidneys of this patient and its distribution is well demonstrated in the roentgenographed autopsy specimen (Fig. 2B).

CASE III. This eleven year old white male was admitted to the Clinical Center for studies of a known renal tubular acidosis. This diagnosis was established at the age of one at the Johns Hopkins Hospital where he was studied because of growth failure. The patient was rachitic and did not respond to vitamin D but responded rapidly to calcium lactate.

Two years prior to admission, bilateral stippled calcification of the kidneys was observed roentgenologically.

Roentgenograms at our hospital demonstrated extensive nephrocalcinosis (Fig. 3). Review of outside roentgenograms showed typical rachitic changes which responded rapidly to lactate treatment.

Comment. This case demonstrates the extensive metastatic calcification and stone formation of the kidneys which may occur in renal tubular acidosis.

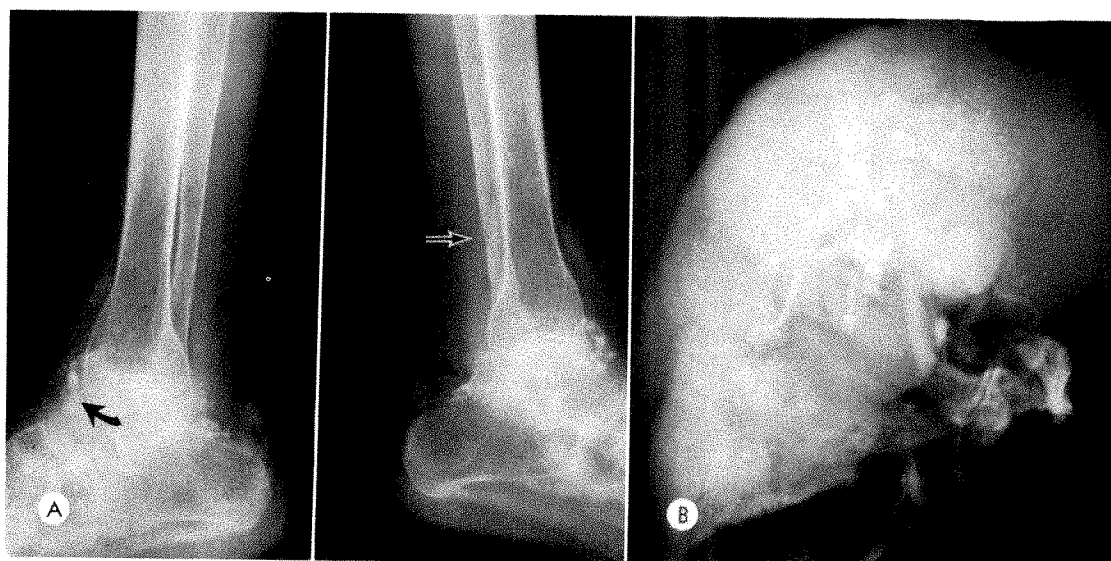


FIG. 2. Case II. Hyperparathyroidism. (A) Para-articular metastatic calcification and subperiosteal bony resorption (arrows). (B) Postmortem roentgenogram of kidney showing extensive nephrocalcinosis not visible on conventional roentgenograms.

CALCINOSIS

Teissier,¹⁵ as early as 1876, was the first to describe calcinosis in man. Since this initial report, numerous articles have appeared describing this most interesting

group of soft tissue calcifications. The calcinosis are divided into 2 main categories; namely, calcinosis universalis and calcinosis circumscripta. There are distinct differences between the 2 as regards the age groups, clinical symptoms, and characteristic sites of calcium deposition.

According to numerous authors, calcinosis universalis usually appears before the age of twenty. It is slightly more common in the female. Clinically, the patients often complain of fatigue and difficulty in locomotion. Muscle aching and a low-grade fever may precede the calcium deposition which occurs first in the subcutaneous tissues but later spreads to the deeper connective tissue septa. The calcification tends to be symmetric and is often beaded and arranged in long bands. The disease is progressive but has a better prognosis than myositis ossificans. On occasion, the skin ulcerates and calcific material is discharged through the skin surface.

Calcinosis circumscripta, on the other hand, occurs in older patients and is usually confined to the terminal phalanges of the fingers and the extensor surfaces of the elbows and knees. Eighty to 90 per cent of the cases occur in women.

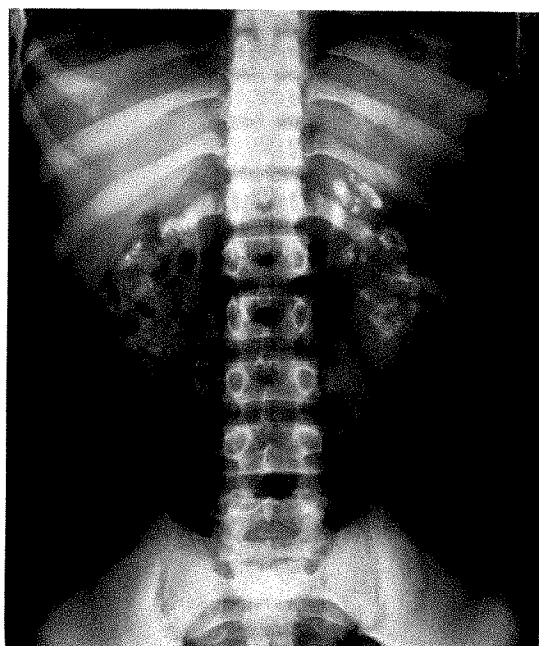


FIG. 3. Case III. Renal tubular acidosis. Extensive calcification and stone formation in both kidneys.

There is a definite relationship between the calcinosis and the collagen vascular diseases, as noted by numerous authors.^{1,6,11,12,14} Conner⁴ believes that most cases of calcinosis are associated with one of the collagen vascular diseases. In fact, Wheeler *et al.*¹⁷ have recommended that the terms calcinosis circumscripta and calcinosis universalis be abandoned as they are purely descriptive. They suggest that these terms be used only when identified with the primary disease, *e.g.*, dermatomyositis with universal calcification. The authors concur with the opinion of Wheeler and associates.

ILLUSTRATIVE CASES

CASE IV. This patient was a twelve year old white male admitted to the Clinical Center with a history of leg aching, low-grade fever, weakness, and fatigue, with onset of symptoms four years prior to admission. Subsequently, muscle wasting and extensive subcutaneous and muscular calcification developed. Positive physical findings consisted of muscular wasting and roentgenographic evidence of widespread cal-

cification. The serum calcium was normal.

Roentgen changes were considered typical of this disease entity. Extensive calcification was present in the subcutaneous tissues of legs, arms, abdominal wall, thorax and buttocks (Fig. 4A). The deposits were beaded in appearance and tended to be arranged in bands (Figs. 4B).

Comment. This patient presented all of the characteristics of calcinosis universalis. His symptoms, age at onset, and roentgen findings were typical. The serum calcium, phosphorus, and pH were normal.

CASE V. This fifty-six year old white female was in good health until five years prior to admission when she noted small, firm deposits under the skin of her forearms and fingers. Many of these areas subsequently ulcerated and discharged calcareous material. The serum calcium was 10.4 mg. per cent and serum phosphorus 4 mg. per cent. Skin biopsies revealed atrophic soft tissue changes with subcutaneous calcifications.

Roentgenograms demonstrated soft tissue calcifications of the knees, hands, and forearms (Fig. 5A). The skin of the hands was atrophic

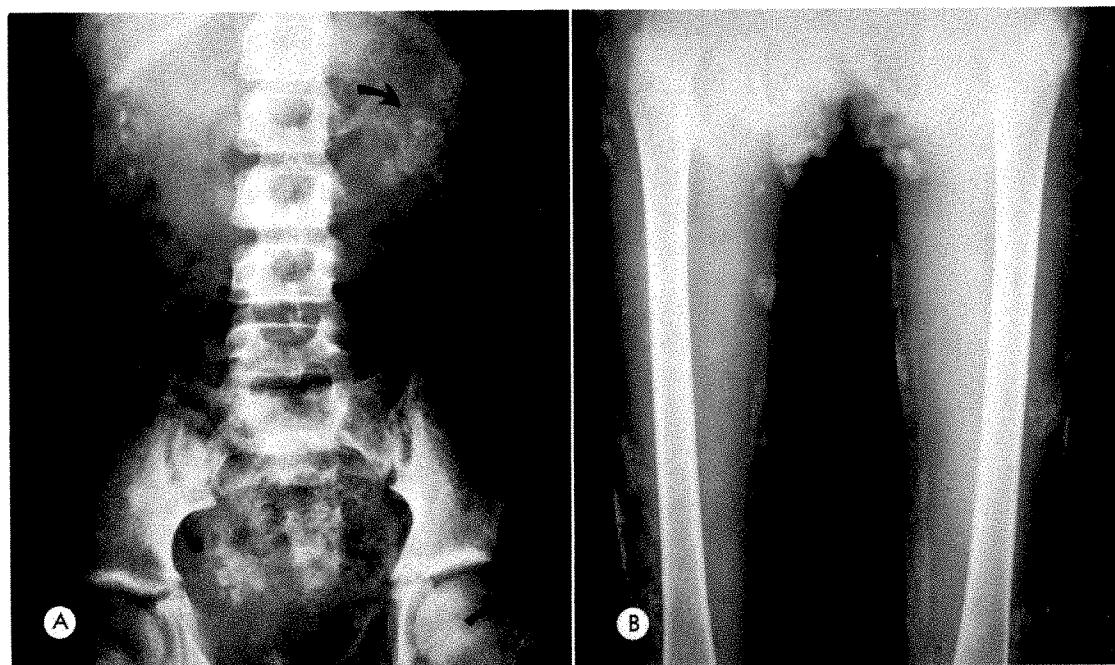


FIG. 4. Case IV. Calcinosis universalis. (A) Note widespread calcification of the subcutaneous tissues of the abdominal wall and pelvic area (arrows). (B) Characteristic beaded appearance well demonstrated in subcutaneous tissues of legs.

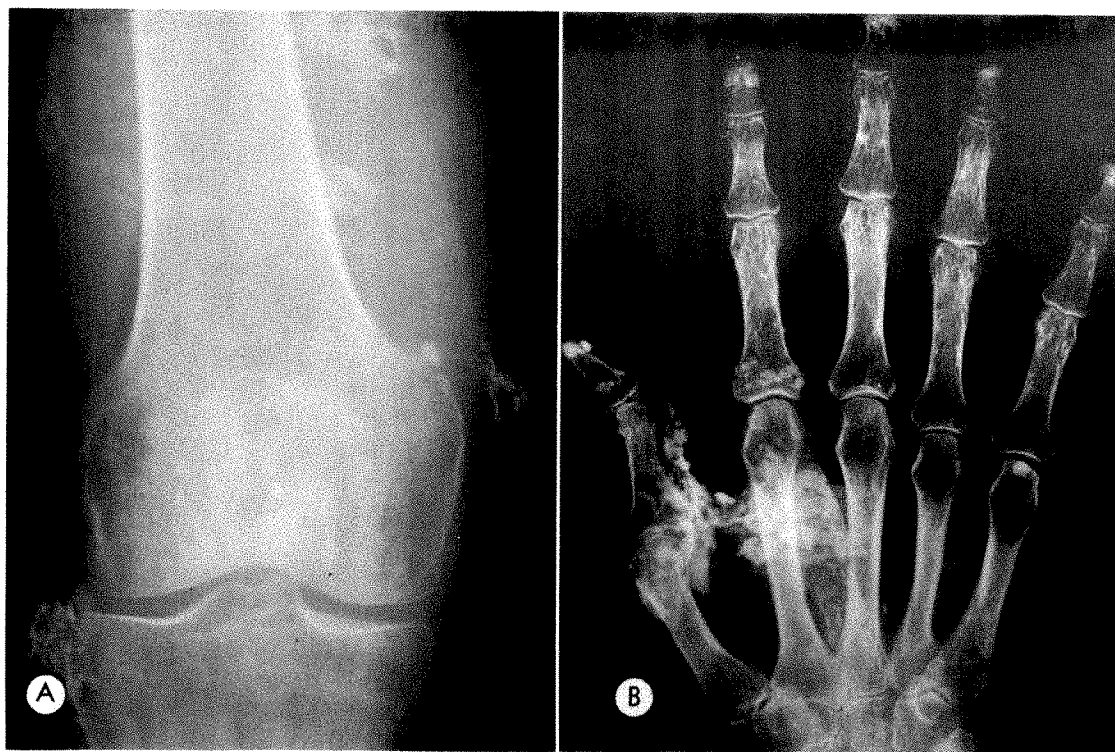


FIG. 5. Case v. Calcinosis circumscripta. (A) Calcific deposits circumscribed and confined to subcutaneous tissues. (B) Note destructive changes in distal phalanges as well as calcifications associated with scleroderma.

and there were destructive changes of the terminal phalanges (Fig. 5B).

Comment. This patient is representative clinically and roentgenologically of a typical example of calcinosis circumscripta associated with scleroderma.

CASE VI. This forty-eight year old female was admitted to the Clinical Center with a history of painful swelling of hands and wrists. A diagnosis of rheumatoid arthritis had been made elsewhere. Treatment with steroids resulted in subjective improvement. A biopsy of the right thigh six years prior to admission was followed by formation of a chronic sinus tract with discharge of calcium. Extensive studies led to a diagnosis of calcinosis universalis. The serum calcium and phosphorus levels were normal.

Roentgenograms demonstrated extensive calcific deposits in the soft tissues surrounding the pelvis (Fig. 6A) and in the left axillary region (Fig. 6B). There were roentgenologic changes of the hands and wrists compatible with rheumatoid arthritis. Soft tissue calcifications were also visualized in the extremities.

Comment. The calcifications were extensive, surrounding the pelvis, and some of the deposits were within tendons and muscles. This is not unusual for calcinosis universalis; in calcinosis circumscripta the calcific deposits are confined to the skin and subcutaneous tissues. This patient was older than most patients with calcinosis universalis.

DYSTROPHIC CALCIFICATION

This is the most common type of pathologic calcification. The calcific material is deposited in devitalized or degenerated tissues such as scars, areas of necrosis, areas of fatty degeneration, and infarcts.² The deposition of calcium may be facilitated by a localized increase of alkalinity. The serum calcium and phosphorus are usually normal but an elevation of either of them expedites the dystrophic calcification. Many infections, granulomata, parasitic infestations, and degenerative neo-

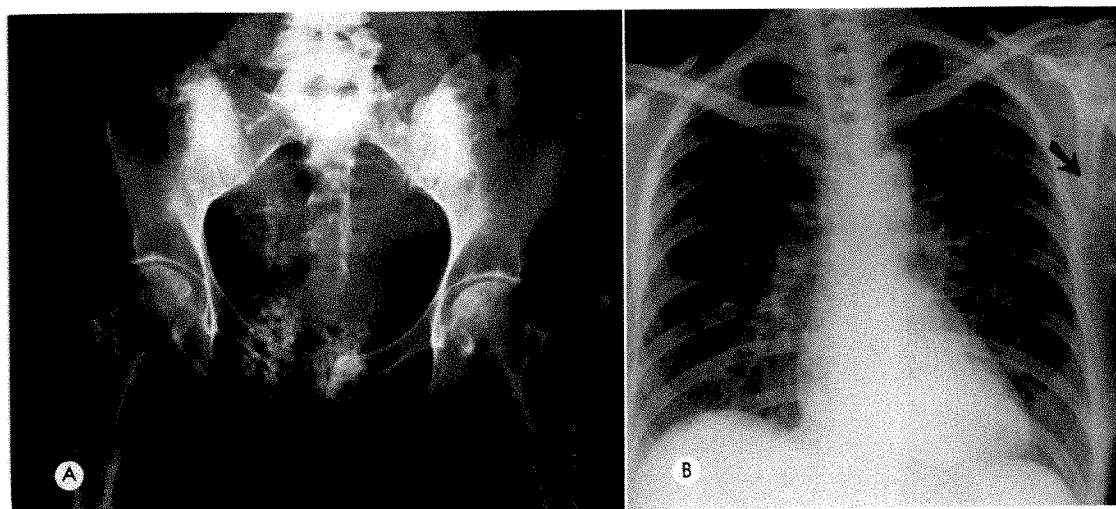


FIG. 6. Case vi. Calcinosis universalis. (A) Calcifications in this patient were located subcutaneously and also involved muscles and tendons. (B) Note calcific deposits in left axilla (arrow).

plasms are detected roentgenologically as a result of associated dystrophic calcifications.

ILLUSTRATIVE CASES

CASE VII. This twenty-eight year old white female was admitted to the Clinical Center for treatment of a parasitic infestation. She had lived in equatorial Africa for four years. Following her return to the United States, she experienced intermittent urticaria and serpentine wheals on the skin. Laboratory findings

revealed a marked eosinophilia (36 per cent). Repeated blood examinations were positive for microfilariae which were identified as *Acanthocheilonema perstans*.

Roentgenograms demonstrated several linear and spherical calcific deposits in the subcutaneous tissues, chiefly in the hands (Fig. 7) and feet.

Comment. The history, laboratory and roentgenologic changes confirmed the clinical diagnosis of filariasis. The calcific de-

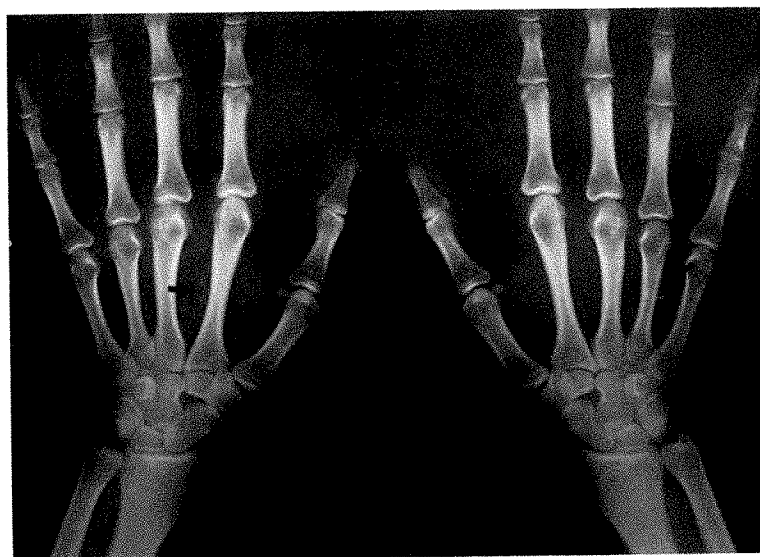


FIG. 7. Case vii. Filariasis (*Acanthocheilonema perstans*). Linear and spherical calcific deposits represent calcified, dead filaria.

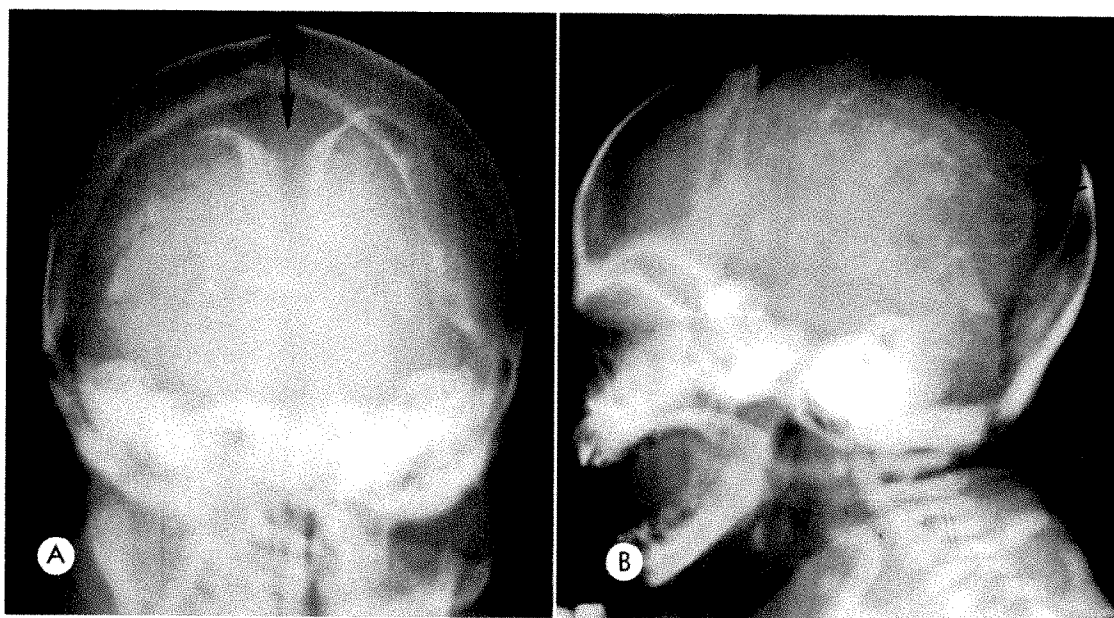


FIG. 8. Case VIII. Cytomegalic inclusion cell disease. (A) Anteroposterior skull roentgenogram showing dilated ventricles outlined by calcifications (arrow). (B) Lateral skull roentgenogram delineating posterior extent of dilated ventricles (arrow).

posits, which occur in dead adult parasites,¹³ are classified as dystrophic in type in accordance with the previously discussed category.

CASE VIII. This Negro infant had had a history of intermittent convulsions, lethargy, and irregular respirations since birth. The patient was microcephalic. Studies of the urinary sediment revealed large cells with cytoplasmic and intranuclear inclusion bodies. The patient died within five days and at autopsy cytomegalic inclusion cells were found in the liver, kidneys, spleen, and lungs. The brain was not examined.

Skull roentgenograms confirmed the presence of microcephaly and showed multiple intracranial calcifications outlining the large dilated ventricles (Fig. 8, A and B).

Comment. The roentgenologic findings were considered pathognomonic of cytomegalic inclusion cell disease. This diagnosis was confirmed at autopsy. The case is included in this discussion as an interesting example of dystrophic calcification.

CASE IX. This fifty-eight year old white female was well until January, 1961 when she had an episode of dizziness, nausea, dysarthria

and aphasia. Studies elsewhere revealed calcification of the basilar ganglia. She was referred to the Clinical Center for evaluation of parathyroid function. Serum calcium and phosphorus were normal, and extensive metabolic studies were thought to rule out parathyroid disease. Discharge diagnoses were (1) recent cerebral vascular accident and (2) idiopathic calcification of the basal ganglia.

Skull roentgenograms (Fig. 9, A and B) revealed dense calcifications of the basal ganglia.

Comment. Many patients with calcifications such as these have hypoparathyroidism, but idiopathic calcification in the basal ganglia has also been reported.² Pathologically, basal ganglion calcification consists of depositions of amorphous calcium salts in degenerative colloid material in and around the finer cerebral blood vessels.

HETEROTOPIC BONE FORMATION

Heterotopic bone formation may occur adjacent to normal bone or far removed from it.⁹ Myositis ossificans progressiva represents the most impressive roentgenologic example of this type of abnormal

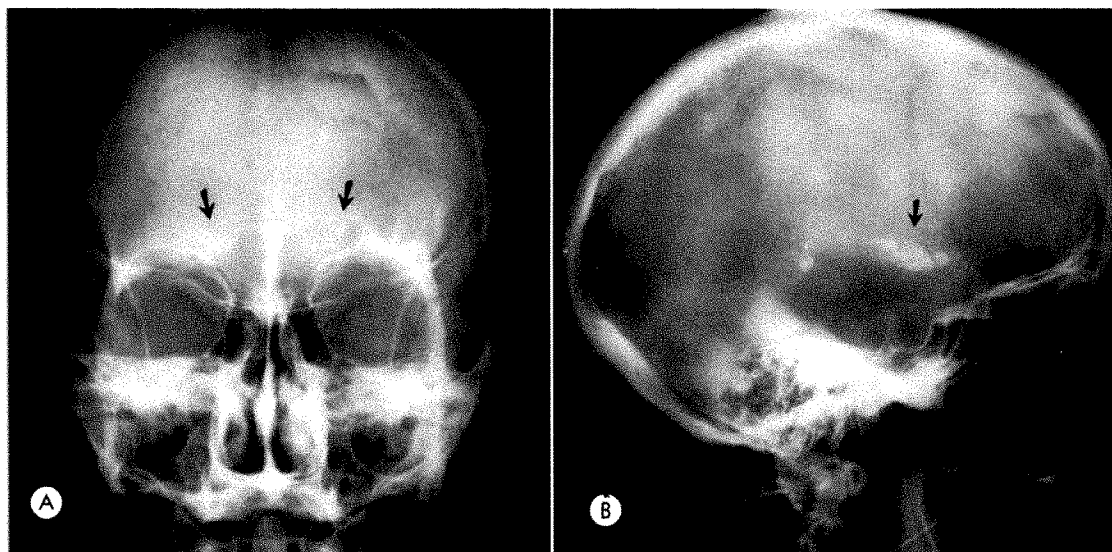


FIG. 9. Case ix. Idiopathic calcification of basal ganglia. (A) Anteroposterior roentgenogram showing bilateral location of calcified ganglia. (B) Lateral roentgenogram showing extensive, dense calcifications in typical location.

bone formation. Traumatic myositis ossificans is a local form of bone production occurring secondarily to a hematoma. It is well known that ordinary fibroblasts are capable of bone formation under certain conditions. The serum calcium, phosphorus and pH are usually normal in these patients. It is believed that localized devitalization of tissues predisposes to the abnormal bone formation associated with trauma; the pathogenesis of myositis ossificans progressiva is obscure. Heterotopic bone development may occur in many sites including the insertion of tendons, the soft tissues of paraplegics,⁷ and postoperative abdominal scars.¹⁰

ILLUSTRATIVE CASES

CASE X. This fifty-six year old Negro male was known to have mild diabetes. Three and one half years prior to the present hospitalization, he had had a Billroth Type I operation for a gastric ulcer. Pertinent history and physical findings consisted of the gradual development of a firm, hard, nontender mass in the abdominal scar. This was quite apparent on physical examination. The chemical findings in the serum were entirely normal.

Roentgenograms demonstrated a linear, branching, bony density within the abdominal

scar. The roentgen characteristics were those of true bone (Fig. 10).

Comment. This case is presented as an interesting example of heterotopic bone

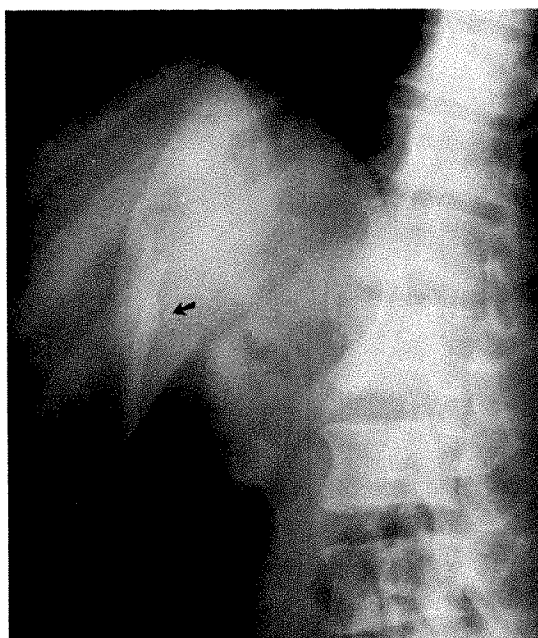


FIG. 10. Case x. Myositis ossificans localisata. Right posterior oblique roentgenogram of abdomen demonstrating true bone formation (arrows) in abdominal scar following surgery.

formation in a postoperative abdominal incision. The ossification presumably resulted from local bleeding, devitalization of tissue, and atypical functioning of fibroblasts with bone formation. Similar cases have been reported.¹⁰

CASE XI. This nine year old white male was admitted with a history of progressive limitation of motion since the age of two. Shortness of the thumbs and of the large toes had been present since birth. Calcific masses in the subcutaneous tissues were first palpable at the age of three. These subsequently became larger in size, more widespread in distribution, and were associated with marked limitation of motion. On physical examination these masses were readily palpable over the posterior thorax, neck, and abdominal wall. The serum calcium, phosphorus, and pH were normal.

Roentgenograms showed extensive ossification of the muscles with bony bridging between ribs, scapulae, and vertebrae (Fig. 11*A*). Congenital shortening of large toes and thumbs was also demonstrated (Fig. 11*B*).

Comment. Myositis ossificans progressiva is a most interesting abnormality, usually appearing before the age of six and characterized by progressive ossification of the connective tissues of muscles. In a large percentage of patients, developmental ab-

normalities of the great toes and thumbs are present. The etiology is unknown and treatment is unsuccessful. This patient presented the characteristic clinical and roentgenologic findings of this disease process.

CASE XII. This forty-six year old white female sustained an injury to the posterior aspect of the left leg in an automobile accident. There was gross discoloration and a large hematoma at the site of trauma. This gradually resolved but a hard, calcific mass slowly developed posterior and superior to the knee joint.

A roentgenogram of the left leg demonstrated ossification of the soft tissues (Fig. 12).

Comment. This case represents an excellent example of a localized myositis ossificans following trauma. Soft tissue calcifications following injury may disappear but once ossification occurs it is usually permanent. This type of lesion may cause disability due to limitation of motion.

VASCULAR CALCIFICATION

Vascular calcifications are usually classified as arteriosclerotic (with intimal calcification secondary to atheromatous degeneration) or as Mönckeberg's sclerosis (with calcification in the medial wall). In disease processes such as hyperparathyroidism or

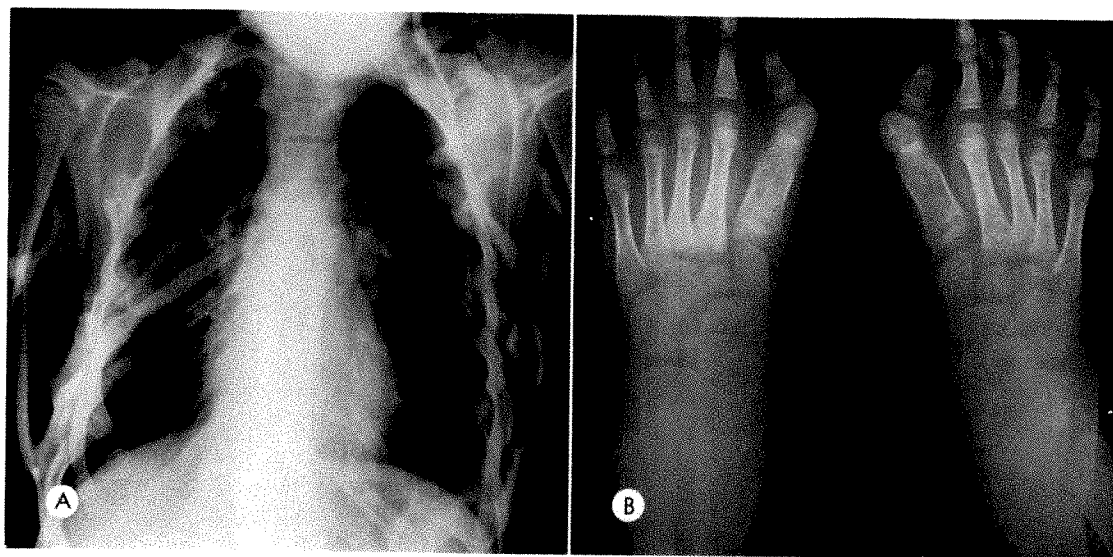


FIG. 11. Case XI. Myositis ossificans progressiva. (*A*) Typical roentgenographic findings of widespread bony bridging between ribs, scapulae and vertebrae. (*B*) Congenital deformity and shortening of large toes which often accompany myositis ossificans progressiva.

vitamin D intoxication⁸ in which the serum calcium is often elevated, vascular calcification is accentuated.

ILLUSTRATIVE CASES

CASE XIII. This twenty-six year old white female was well until the age of eighteen when she noted blotches on her skin. The skin subsequently became dry and pigmented, and a large quantity of her hair fell out. She became amenorrheic and demonstrated marked premature aging. Studies during hospitalization revealed nephrocalcinosis associated with an elevated serum calcium (12–14 mg. per cent). Multiple lymph node biopsies showed a noncaseating granuloma.

On physical examination the patient appeared approximately sixty years of age, although only in her twenties. Roentgenograms



FIG. 12. Case XII. Traumatic myositis ossificans. True bone formation demonstrated following traumatic hematoma.



FIG. 13. Case XIII. Boeck's sarcoid. Widespread vascular calcifications associated with hypercalcemia. Note also metastatic calcification of soft tissues (arrow).

showed extensive vascular calcification (Fig. 13).

Comment. This patient is presented as an interesting example of extensive vascular calcification. Clinically and histologically, the most likely diagnosis was considered to be Boeck's sarcoid. The vascular calcifications were the most extensive encountered to date in our X-ray Department.

CASE XIV. This forty-three year old white male was admitted with complaints of chest pain and tingling of the hands. He was known to have had syphilis, which had been treated with penicillin.

A lateral chest roentgenogram (Fig. 14) clearly delineated a fusiform aneurysm of the ascending aorta with extensive calcification.

Comment. Whereas syphilis was once the most frequent cause of calcification of the ascending aorta, its prevalence has decreased appreciably in recent years. Pathologically, the changes observed result from a destructive mesaortitis. Calcification occurs in the medial wall as well as in the intima.

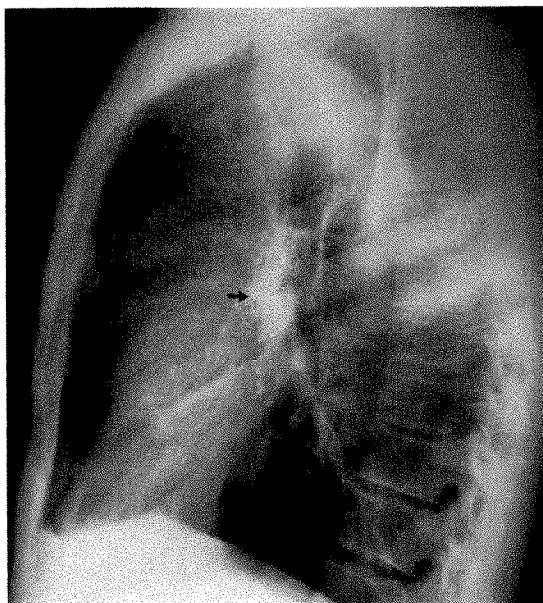


FIG. 14. Case xiv. Syphilitic aortitis. Fusiform aneurysm with calcification of wall.

STONE FORMATION

This category, like the preceding one, is well known to radiologists. Stones may form in many areas but the two most common sites are the kidneys and gallbladder. The same factors that play an important role in metastatic calcification may lead to stone formation, *i.e.*, an elevation in the concentration of calcium or phosphorus in fluids, increased localized alkalinity, and devitalization of tissues. Additional factors include stasis, infection, and debris formation. When there is obstruction of the cystic or common ducts, a nidus of tissue or cells serves as an excellent precursor for calcium deposition and gallstone formation. Urinary calculi may be formed under similar conditions.

ILLUSTRATIVE CASE

CASE XV. This forty-seven year old white male was admitted to the hospital with a history of spinal tumor which was biopsied at the age of three and diagnosed as malignant neuroblastoma. The patient was treated by radiation and subsequently operated upon at the age of eleven by Dr. Cushing. The tumor at this time was classified as an unusual ganglio-

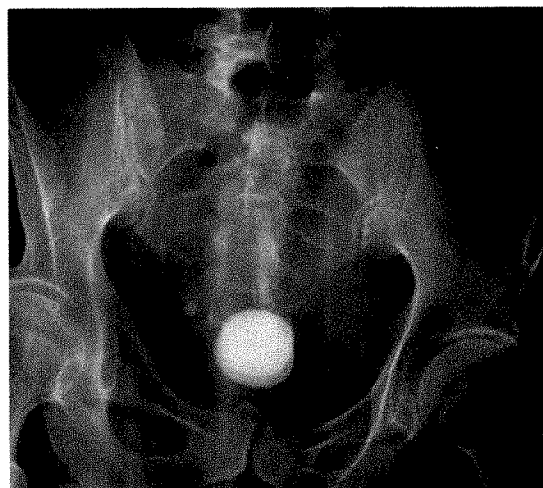


FIG. 15. Case xv. Paraplegia with bladder calculus formation. Note prostatic calculi, as well as small calculus in bladder diverticulum.

neuroma. Following operation, the patient was left with spastic paraplegia.

A roentgenogram of the pelvis (Fig. 15) revealed a large bladder calculus as well as a small calculus within a diverticulum on the right side of the bladder. The patient also had multiple prostatic calculi.

Comment. Vesical calculi frequently form in a so-called neurogenic bladder. The calculi are attributed to stasis, chronic infection, and trauma due to catheterization. This patient had a long history of recurrent cystitis and stone formation.

SUMMARY

1. Soft tissue calcifications may be classified into 6 categories—metastatic calcification, the calcinoses, dystrophic calcification, heterotopic bone formation, vascular calcifications, and stones.

2. The roentgenologic appearance of each type is illustrated, and brief case histories and brief comments are presented.

3. Metastatic calcification and stones are thought to start with precipitation of calcium phosphate, often in alkaline medium. Dystrophic calcification is thought to occur in damaged tissues; when the damage results from collagen diseases, calcinoses may follow; when it results from

theromata or medial sclerosis, vascular calcification follows. Heterotopic bone may develop upon pre-existing calcification, or *de novo*.

4. The roentgenologist often has a unique opportunity to detect underlying disease by recognizing pathognomonic aspects of soft tissue calcification.

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THE MULTIPLE MYELOMA SYNDROME AND ITS IMPLICATIONS*

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SCARCELY ten years ago, multiple myeloma was considered by most physicians as a malignant tumor of bone, usually involving many parts of the skeleton, with spontaneous remissions, but fatal within five years. It was known that abnormal proteins in the serum and urine were associated with this disease. Only recently, however, has it been possible to study these proteins by a relatively simple technique of electrophoresis using filter paper. These proteins are remarkably homogeneous, and unique in each individual patient.

As a consequence, it is now thought that the essential features of multiple myeloma are proliferation of plasma cells and the presence of abnormal gamma globulins in the serum, urine, or both. Destructive bone lesions may occur late or not at all in the disease; or the skeleton may show only osteoporosis, with hypercalcemia and metastatic calcification in the kidneys and soft tissues. Infiltration of vital organs (heart, kidney) by para-amyloid deposits often is the cause of death.⁸ It is likely that many patients dying in the past of chronic nephritis or myocarditis may have had latent multiple myeloma.⁵

Even when lesions of bone are present, the clinical course of multiple myeloma is by no means as predictable as formerly thought. The "spectrum" of this disease may extend from an indolent local benign lesion of bone, to one which eventually metastasizes, to an eruptive multicentric process involving many bones simultaneously, or to a process identical to leukemia of plasma cell origin with infiltration of bones, lymph nodes, soft tissues and

peripheral blood. This variability is illustrated by the cases that follow.

ILLUSTRATIVE CASES

CASE 1. M.A., a white female of eighty-three years of age, was seen in 1946 complaining of right nasal obstruction of four weeks' duration. A soft gray mass arose from the middle turbinate and filled the right nasal cavity. Roentgenograms showed a tumor in the right antrum (Fig. 1). There was no disease in the skeleton and no abnormal protein in the urine. Serum proteins were not studied.

Biopsy of the nasal mass showed broad sheets of plasma cells oriented on a delicate fibrous and

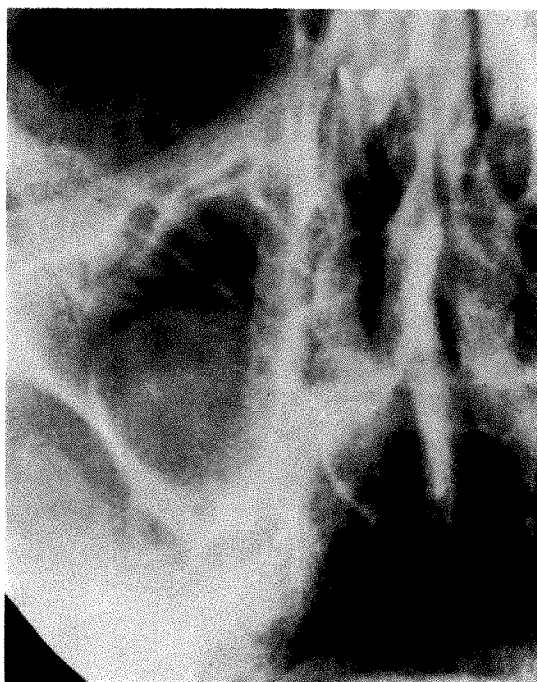


FIG. 1. Case 1. Round tumor in the right maxillary sinus of a white female, 83 years old. Biopsy revealed a malignant plasmacytoma, but the lesion did not recur after treatment with radiation.

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vascular stroma. The appearance was that of a malignant plasmacytoma (plasma cell proliferation in soft tissues).

Roentgen and radon seed therapy resulted in the disappearance of the tumor within six months. The patient remained free of this disease until her death from cardiac failure five years later.

Comment. Most plasma cell tumors of the upper air passages are locally invasive with a tendency toward distant metastases.⁷ In this patient, the histologic pattern indicated a malignant tumor.

However, the favorable clinical course after modest local radiation therapy and the absence of abnormal proteins and skeletal changes pointed to a relatively benign process in this particular patient.

CASE II. E.C., a white female of fifty-nine years of age, was seen in 1946 complaining of recurrent "cysts" of the larynx and gradual thickening of the left faucial pillar of six years' duration. After three local excisions of tissue infiltrated with plasma cells, a sudden explosive enlargement of the cervical, axillary, mediastinal and inguinal lymph nodes and marked enlargement of the spleen occurred (Fig. 2).

The patient became anemic and was found to have hyperglobulinemia. A study of the bone marrow was normal and roentgenograms of the skeleton were negative. Biopsy of a cervical lymph node showed a malignant plasma cell tumor.

With judicious and protracted roentgen therapy, the patient improved slowly. Her death occurred in 1950 from uremia.

Comment. This patient's illness mimicked closely the clinical course of a lymphosarcoma. Only plasma cell proliferation was present associated with the characteristic alteration in serum globulins. There was no involvement of the skeleton.

CASE III. W.C., a white male of fifty-five years of age, was seen in 1945 complaining of left nasal obstruction. A polypoid mass was removed from the left nasal cavity on two occasions with prompt recurrence after each operation. Roentgen and radium therapy was instituted with regression of the local tumor.

In 1948, however, innumerable distant metastases to the skeleton, soft tissues and liver were

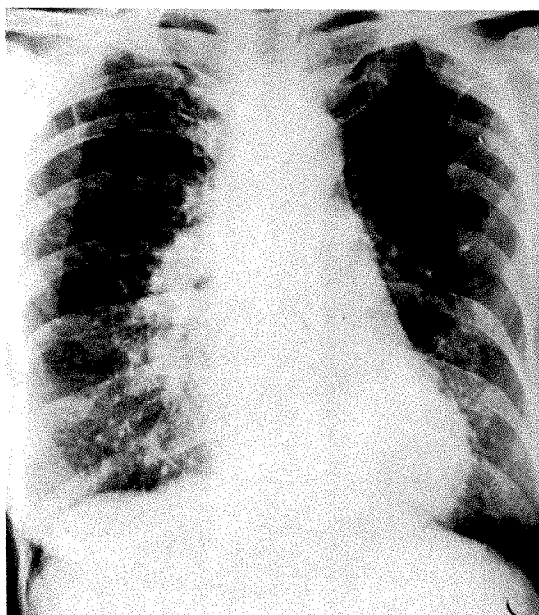


FIG. 2. Case II. Enlarged hilar lymph nodes in a white female, 59 years old, with swelling of all the superficial lymph nodes. The biopsy diagnosis was malignant plasma cell tumor. There were no lesions in the skeleton.

noted (Fig. 3). Biopsies from the nasal cavity, maxillary sinus, clavicle and subcutaneous nodules all showed malignant plasma cell neoplasm. There was hyperglobulinemia.

Roentgen therapy and nitrogen mustard helped relieve pain, but the patient died in 1950.

Comment. This patient showed the typical clinical course of malignant plasmacytoma, with soft tissue, bone and biochemical changes.

CASE IV.* E.M., a white male of twenty-four years of age, was seen in 1954 complaining of pain and weakness in the lower legs and of difficulty in walking of six months' duration. There was some muscle atrophy, bilateral foot drop and loss of vibratory sensation below the knees. Spinal fluid protein was elevated. Serum globulins were elevated and abnormal. Roentgenograms of the skeleton showed only a lesion in the right ilium (Fig. 4a). Myelography was negative. Biopsy showed a malignant plasma cell tumor.

Roentgen therapy with a dose of 4,000 r in

* Courtesy Dr. James S. Deakins, Veterans Administration Hospital, Philadelphia, Pennsylvania.

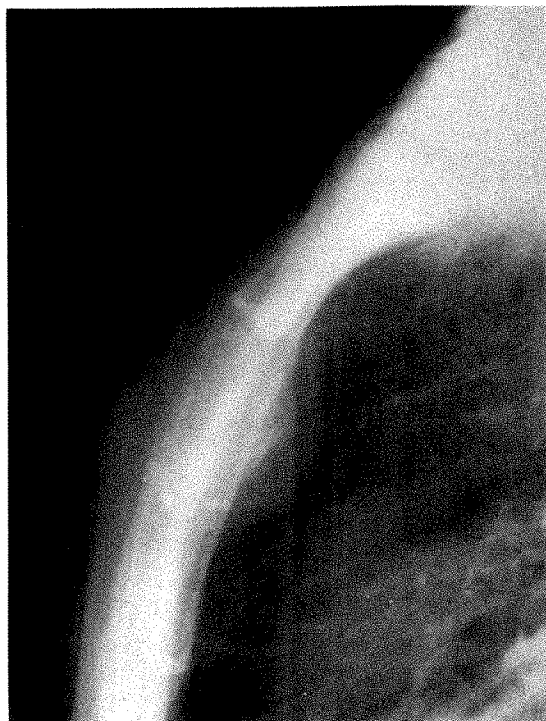


FIG. 3. Case III. Large tumor involving the sternum and adjacent structures in a white male of 55 years. A polypoid mass had been removed from the left nasal cavity three years before. The diagnosis was malignant plasmacytoma.

six weeks was given to the tumor. The patient's pain was relieved, and has not returned. The bilateral foot drop has not improved.

The patient has been on a maintenance dose of urethane to the present time. The abnormal globulin in the serum has disappeared and the spinal fluid protein has returned to normal. The lesion in the right ilium has become partially calcified (Fig. 4*b*).

Comment. This malignant solitary myeloma has been controlled by vigorous therapy for an unusually long time. In some patients with malignant myeloma, neurologic deficits occur which cannot be explained by tumor deposits or amyloid in the central nervous system. These patients show "toxic" changes in myelin sheaths and nerve axis cylinders which may be related to biochemical changes in body proteins.⁹

CASE V. H.P., a white female of sixty-five years of age, was seen in 1953 complaining of severe pain in the neck, right shoulder and left

hip of six months' duration. Roentgenograms of the skull showed innumerable areas of bone destruction (Fig. 5*a*). Material from the bone marrow showed malignant myeloma. Bence-

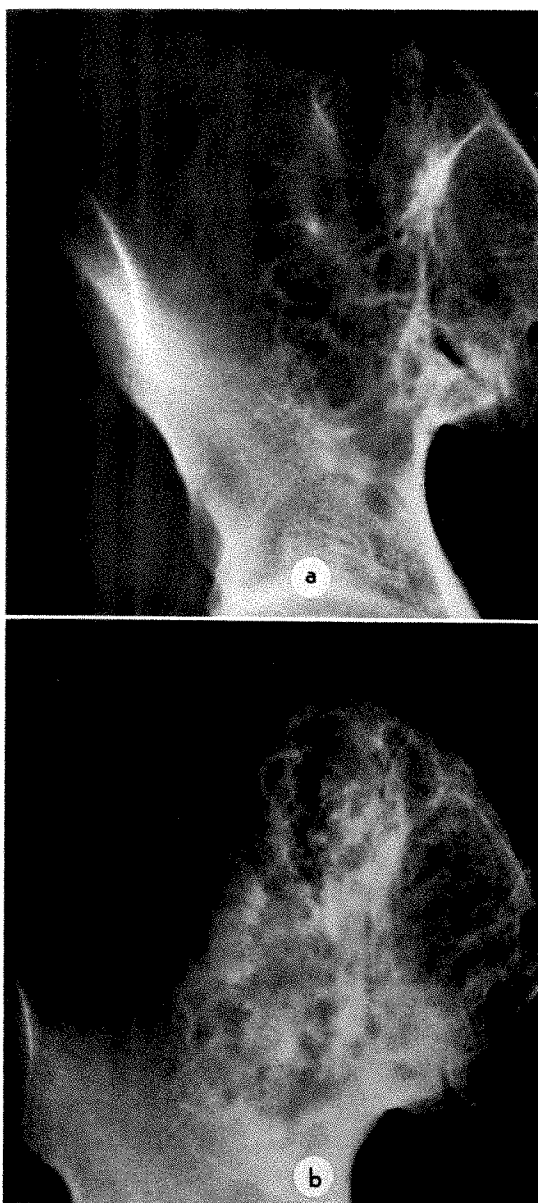


FIG. 4. Case IV. (a) Destructive lesion in the right ilium in a 24 year old white male complaining of pain and weakness in the lower extremities for six months. Biopsy revealed malignant plasma cell tumor. (b) Same lesion, three months after roentgen therapy with a dose of 4,000 r delivered in six weeks. Note calcification within the tumor. The pain was relieved but the weakness of the legs remained.

Jones protein was present in the urine. The blood serum proteins were normal.

The patient improved considerably while on urethane therapy, and lived for three years.

Comment. Except for the normal serum protein, this patient presented the classic course of multiple myeloma. The striking lesions in the bones were once thought to be characteristic of this disease (Fig. 5*b*).

CASE VI. S.R., a white male of fifty years of age, had a tumor removed from the left nasal cavity in 1941. This recurred in 1945 and was again removed. In 1955 a painful lesion in the right heel was biopsied and was noted to resemble the previous nasal lesions. All were diagnosed as malignant plasma cell tumor.

Since that time, the patient had two more tumors removed from the nose and nasopharynx with subsequent roentgen therapy. During this period he also developed painful lesions in each tibia, the left middle finger and both elbows. In each instance, roentgen therapy relieved the pain but the characteristic destructive changes in the bones remained (Fig. 6).

The histologic appearance of tissue removed from the nasopharynx on four occasions and from several of the bone lesions has been characteristic of malignant plasma cell tumor (Fig. 7). The serum proteins and urine have been

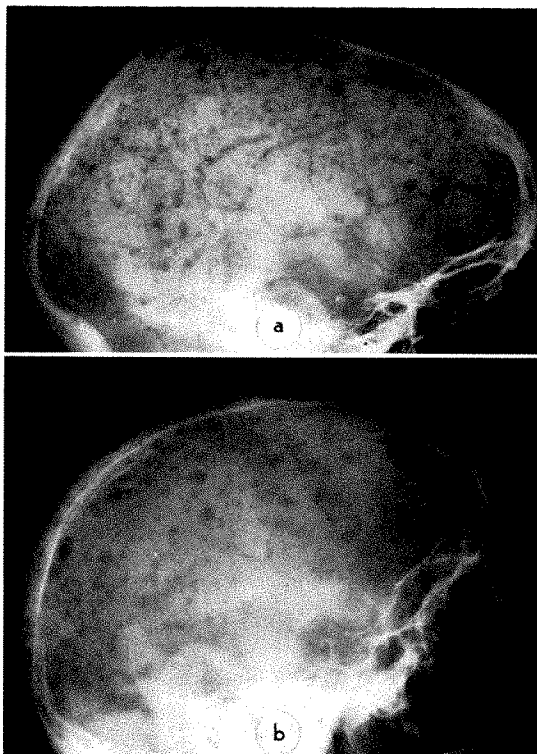


FIG. 5. (a) Mottled small areas of destruction in the skull of a white 65 year old female (Case v) with multiple myeloma. This is the classic appearance described in text books. (b) Mottled small areas of destruction in the skull of a white 55 year old male with carcinoma of the lung. The appearance is identical to that in a.

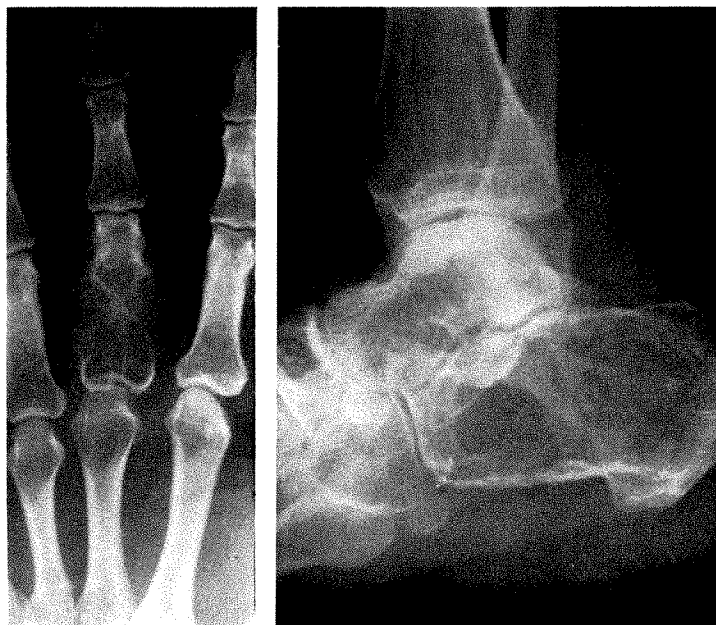


FIG. 6. Case VI. Destructive lesions in the phalanx and os calcis of a white male aged 64, whose illness began 14 years earlier with a recurrent tumor in the nasopharynx. Biopsy of the soft tissue mass and the os calcis revealed malignant plasma cell tumor.

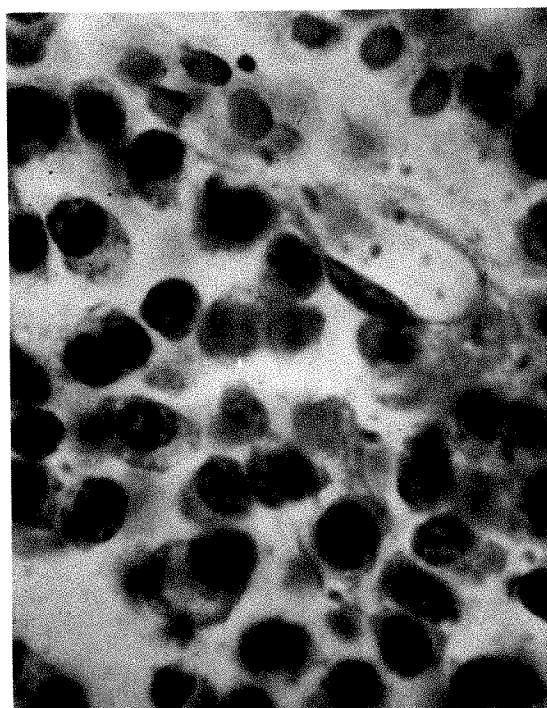


FIG. 7. Case VI. Plasma cells obtained from the os calcis showing characteristics of a malignant tumor ($\times 1000$).

examined many times, and no abnormal proteins have been found.

Comment. For many years the patient's disease has been crippling but not mortal. In spite of active proliferation of abnormal plasma cells, the clinical course has not resembled that of a malignant tumor, and no disturbance in protein synthesis has occurred.

DISCUSSION

These case illustrations substantiate the statement made by Osserman,² who wrote, "It is now generally agreed that cases of solitary plasmacytoma of bone, multiple plasmacytomas, extra-medullary plasmacytoma, diffuse myelomatosis, and plasma cell leukemia, and most, if not all cases of 'primary amyloidosis' represent clinical and pathological variants of primary plasma cell proliferation. It is also evident that these several clinical patterns overlap . . .

and therefore should be considered parts of a continuous spectrum of disease rather than a group of distinct clinical and pathological entities."

Of greater interest even than this variegated clinical picture, are the biochemical and immunologic aspects of this syndrome of plasma cell proliferation.⁴ In few diseases are the metabolic disturbances so profound as the abnormalities of protein synthesis occurring in multiple myeloma. In the classic case, antibody activity of the normal serum globulin is so depressed that bacterial infections flourish. Putnam⁶ felt that "in this extraordinary parasitism of nitrogen metabolism may lie the key to the understanding of the mechanism of serum globulin synthesis and antibody production."

Most investigators believe that the abnormal proteins found in the blood and urine of many patients with multiple myeloma are produced by the proliferating plasma cells. Indeed, there is no doubt that these abnormal proteins are not only regularly associated with, but are even found within, the plasma cells. This supports the conventional view that multiple myeloma is a malignant tumor with prominent and morbid functional overtones.

However, in a few patients large amounts of anomalous serum and urinary proteins may be present with no histologic evidence of disease or plasma cell proliferation. This suggests that such proteins are manifestations of a primary lesion at a chemical level,⁴ and raises the question of an inborn error in metabolism. For this reason Barr¹ believes that abnormal plasma cell proliferation might be a response to rather than the cause of the abnormal proteins.

Finally, there are the rare instances, such as Case VI, where widespread plasma cell tumors may be present for many years without any disturbance in protein metabolism. Here, again, one finds a significant dissociation between plasma cell proliferation and the presence of the distinctive

anomalous protein, found in the text-book disease called multiple myeloma. Furthermore, in these few instances, although plasma cells proliferate, appear malignant histologically, and destroy bone, the clinical course is not that of a malignant tumor, so much as that of a chronic infection.

SUMMARY

Multiple myeloma is a disease of many colors; at one end of the spectrum, it may present as a localized benign tumor; at the other, as an explosive, widely disseminated malignancy.

Multiple myeloma is associated closely, with a fundamental derangement in protein metabolism. This may interfere seriously with the antibody function of the normal serum globulin. The abnormal protein may produce lethal damage to vital organs such as the heart or kidneys.

The significance of the myeloma proteins is a biochemical riddle. If this is solved, one may see a long way down the corridors of some fundamental biologic processes.

Multiple myeloma many times behaves like a malignant tumor; occasionally, like

an inborn error of metabolism, and rarely, like an infection.

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ROENTGENOGRAPHIC ASPECTS OF ARTICULAR PIGMENTED VILLONODULAR SYNOVITIS*

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IN 1941 Jaffe and his co-workers¹⁰ promulgated their classic concept of this disease entity, designating it as pigmented villonodular synovitis, bursitis, or tenosynovitis, as the case may be. After having studied 20 cases of joint involvement, 4 cases of bursal involvement, and 55 cases of tenosynovial involvement, a common basic gross and histopathologic process became evident to them. From the comprehensive surveys of the literature by De Santo and Wilson⁵ and Galloway and associates,⁷ they collected similar cases, which, depending on the import ascribed to the various cellular components, bore a variety of epithets, such as xanthoma, xanthogranuloma, giant cell tumor, myeloplaxoma, chronic hemorrhagic villous synovitis, giant cell fibrohemangioma, fibrohemosideric sarcoma, sarcoma fusigiganto-cellulare, benign polymorphocellular tumor of synovial membrane, and malignant polymorphocellular tumor of synovial membrane. Credit is given to Simon¹⁵ for describing the first circumscribed articular lesion in 1865, and to Moser¹² for describing the first diffuse joint lesion in 1909.

PATHOLOGY

In the opinion of Jaffe's group, the common origin of these lesions is microscopically characterized by hyperplasia and proliferation of undifferentiated connective tissue cells of the synovial membrane to form large numbers of polyhedral or spindle-shaped stromal cells. These cells in turn give rise to lipid-bearing foam cells, hemosideric cells, and multinuclear giant cells and become interspersed among abundant thin-walled blood vessels. Grossly,

the process is manifested by the formation of long, slender, reddish or yellowish-brown, moss-like villi which resemble a "straggly beard" and which, in some areas, become consolidated to form nodules or become entangled and agglomerated to form complex, spongy pads. The lesion may either involve diffusely all ramifications of a synovial cavity, even breaking through the joint capsule, or be circumscribed in an otherwise normal synovial cavity. Jaffe's group postulated evolution from the initial villous pigmented phase to an intermediate nodular and cellular phase, and then to a more sparsely cellular fibrous and hyalinized end stage. Accordingly, they contended that the more nodular and tumor-like tenosynovial lesions, commonly denoted as xanthoma or giant cell tumor, were merely advanced stages and that the other aforementioned lesions were but evolutionary cellular variations of pigmented villonodular synovitis.

ETIOLOGY

Suffice it to say that the cause and true nature of this condition are unknown. Jaffe and his colleagues reasoned that the process is an inflammatory reaction to an unknown agent which is *not* trauma, irritation from local hemorrhage, local lipid imbalance, or infection. Wright¹⁶ was firmly at variance with the inflammatory concept and championed neoplasia as an etiologic factor. He related this condition to the ordinary malignant synovioma, insisting that benign giant cell synovioma is the appropriate designation for this disorder. Others contended that the condition is an intermediate state between distinct inflam-

* Abridgment of thesis submitted by Dr. Smith to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Radiology.

mation and neoplasia. A report of metastasis or malignant change by this pathologic process has not been found.

INCIDENCE AND LOCALIZATION

The incidence of pigmented villonodular synovitis involving large joints is extremely low, but it is probably higher than the reports in the literature indicate. The lack of uniform terminology, particularly in the older literature, and difficulty in determining articular involvement have thwarted accurate compilation of all cases in the literature. A search through the English literature, with the exclusion of phalangeal lesions, yielded 185 reported cases acceptable as articular pigmented villonodular synovitis. The previously unreported cases of the present series bring the total to 202 cases. As has been described by many investigators, an overwhelming predilection exists for the lower extremity, especially the knee; 164 cases involved the knee, 14 the ankle, and 12 the hip. Lesser sites of involvement were the tarsus and carpus, with 4 cases each, followed by the elbow and shoulder, with 3 cases and 1 case, respectively.

Only 2 exceptions to monarticular involvement were found. Concurrent involvement of both knees was reported by Greenfield and Wallace.⁹ Sequential involvement of a knee ten years after the involvement of the opposite knee was reported by Friedman and Schwartz,⁶ but tissue confirmation of the diagnosis was lacking for one of the lesions.

The type of gross pathologic involvement could be ascertained in 169 lesions, including those in the present series. In 104 lesions the involvement was diffuse, and in 65 lesions it was circumscribed.

SEX AND AGE

The sex of the patient was known in 145 cases, including those in the present series; a female predominance of 80:65 was found. It is generally agreed that pigmented villonodular synovitis is a disease of young adults. The age at the time of diagnosis

was indicated in 112 cases, including those in the present series, and occurrence was found to be most frequent in the third and fourth decades. The youngest patient was twelve years old² and the oldest was sixty-eight years of age.¹⁰ Diffuse and circumscribed lesions were similar in age distribution.

SIGNS AND SYMPTOMS

The signs and symptoms are generally not considered to be specific, but they may suggest the proper diagnosis. In a series of 34 cases, including 2 bursal lesions, Atmore and associates¹ reported that the duration of symptoms before definitive treatment was undertaken ranged from six months to twenty-five years, with an average of six and one-half years. In their 34 cases, swelling (except in the hip) and minimal to moderate pain were the most common complaints and the usual initial symptoms. Limitation of motion and locking of the involved joint were also described. Typically, the clinical course is reported to be progressive, and exacerbations of symptoms occur not infrequently; effusions requiring repeated aspirations may have occurred.

On physical examination, tenderness is often present, although it is usually minimal. Swelling or focal masses may be palpable about the joint and may mechanically limit motion. Aspiration of an associated effusion yields xanthochromic or sanguineous fluid that may be high in cholesterol content, but no hypercholesterolemia or other findings suggestive of a systemic disease are present. Fever, leukocytosis, and an elevated erythrocyte sedimentation rate are not associated with this condition.^{1,5,10}

REPORTED ROENTGENOGRAPHIC FINDINGS

Reports concerned primarily with the roentgenographic features of this condition are few; other information is limited to generalizations or roentgenographic descriptions accompanying individual case reports.

With a positive approach, Lewis¹¹ refuted

the reported ineffectuality of roentgenographic examination by characterizing the roentgenographic appearance of this condition as it occurs diffusely in the knee. Recognizing that the appearance is frequently indistinguishable from that of intracapsular joint tumors, particularly synovial sarcoma, he typified the features of the diffuse lesions as follows: "bones of a young adult; monarticular involvement; excessive amount of synovitis, which may appear smooth in outline and homogeneous in density, but is particularly diagnostic when it is, in part at least, nodular in outline and density, as is frequently the case; joint spacing symmetric and normal, giving no indication of cartilage abnormality; completely normal appearing bones, without even osteoporosis; no evidence of thigh or leg atrophy." If the nodular soft-tissue masses are partly or wholly outside the joint capsule, if the lobulated mass contains scattered and irregular deposits of lime, or if the soft-tissue lesion has invaded bone, he contended that synovial sarcoma was the most probable diagnosis. Circumscribed lesions were demonstrable in some instances, but in his opinion they were insufficiently distinctive to be diagnostic.

Following Lewis's lead, Breimer and Freiburger⁴ further characterized the roentgenographic findings of this condition, stating that the occurrence of distinct lesions of bone had not been sufficiently stressed. Including 4 cases of tenosynovial involvement, they reported 9 cases that exhibited sharply circumscribed erosions and unilocular and multilocular cysts having thin sclerotic margins adjacent to the articular cortex of the involved joint; the lesions were associated with a nodular mass. They attributed the osseous erosions to pressure by the soft-tissue mass on articular cartilage and cortical bone, and ascribed formation of cysts to expansion of the mass within softer cancellous bone. They explained the paucity of osseous lesions about the commonly involved knee by the large synovial space of this joint, which allows the mass to expand without causing undue pressure.

Reports of pneumoarthrography were found in 6 cases involving the knee.^{3,9,14} In 5 of these cases results of this examination were regarded as being negative and non-contributory. In 1 case,³ in which routine roentgenograms were interpreted as being negative except for soft-tissue swelling, pneumoarthrography revealed numerous, irregular soft-tissue marginal projections into the gas shadow; this appearance was considered to be consistent with the diagnosis of pigmented villonodular synovitis.

PRESENT SERIES

A search through the files of the Mayo Clinic yielded 50 cases of pigmented villonodular synovitis involving large joints. The involvement was monarticular in each of these cases. Included in this group are 33 cases from the reports of Ghormley and Romness,⁸ Atmore and associates,¹ and Peterson and co-workers.¹³ Seventeen of this group of 50 cases have not been described before.

In 36 of these cases preoperative roentgenographic examinations of 38 lesions (2 patients had a recurrence) had been made and they form the basis for this analysis. The original roentgenograms were available in 35 instances and photographs of discarded roentgenograms in 3 instances. There were no pneumoarthrograms for study.

The clinical records and pathologic features in each case were reviewed, and the diagnosis was reaffirmed. From each lesion multiple tissue sections stained with hematoxylin and eosin and, in many instances, stained for iron, were studied microscopically. Gross surgical specimens of 36 lesions were studied and, together with surgical descriptions, were correlated with corresponding roentgenograms. Of the 36 lesions, the gross type of pathologic involvement was diffuse in 32 instances, 24 of them involving the knee; in the remaining 4 instances, all of them involving the knee, the lesions were circumscribed. Gross specimens of lesions of the knee were not available in 1 patient who had received definitive surgical treatment elsewhere and in 1

patient who declined synovectomy after the diagnosis had been established by needle biopsy. The lesions were judged to be diffuse in both of these cases on the basis of clinical findings.

ROENTGENOGRAPHIC OBSERVATIONS
(TABLE I)

Soft-Tissue Changes. Description of the soft-tissue manifestations need not always be limited to swelling, because the gross pathology of this condition may be reflected on the roentgenogram, depending on the local anatomy, the tissue gradients of fat content, and the nature of the abnormal tissue. Gradations that may be seen range from minimal hyperplasia of the synovium that is sometimes indistinguishable from effusion to distinct tumefactions that sometimes vary in density and have a lobular outline. Increased content of iron may enhance detection of the synovitis.

Soft-tissue abnormalities of a joint may be intra-articular or extra-articular, or both. Basically, pigmented villonodular synovitis of the large joints is intra-articular, but, as has been mentioned, it may break through the capsule and appear

extra-articularly. Rarely, a lesion may be entirely extra-articular.¹² Visualization of an expanded synovial sac or detection of synovitis within the confines of a joint indicates intra-articular involvement. Remoteness of the soft-tissue findings and their lack of conformity to the anatomic limits of the joint suggest extra-articular involvement. Fortunately, the joint most commonly involved—the knee—lends itself favorably to evaluation of soft tissue, because expansion of the suprapatellar recess and the capsule is usually readily recognized. Intra-articular synovitis can be identified with reasonable accuracy along the anterior inferior convexity of the femoral condyles, where it is outlined by the infrapatellar fat pad as seen in the lateral view.

Roentgenographic evaluation of the 24 diffuse lesions of the knee disclosed soft-tissue manifestations of synovitis in 22 instances. In each of these 22 lesions the involvement was judged to be intra-articular (Fig. 1), and, in addition, 5 of the lesions appeared to have concomitant extra-articular involvement (Fig. 2). Correlation with the pathologic findings pointed

TABLE I
ROENTGENOGRAPHIC OBSERVATIONS IN PRESENT SERIES

Lesions	Knee		Hip	Ankle	Shoulder	Carpus	Total
	Diffuse	Focal					
(Total no. of lesions)	24	4	7	1	1	1	38
Soft-tissue changes	22	2	0	1	0	1	26
Intra-articular	22*	1	0	?	0	?	23
Synovitis	18	1	0	0	0	0	19
Expanded synovial sac	17	1	0	0	0	0	18
Extra-articular	5	1	0	?	0	?	6
Tumefactive	10	1	0	1	0	1	13
Lobular outline	9	0	0	1	0	1	11
Varying density	5	0	0	0	0	0	5
Local osseous changes	8	1	7	1	1	1	19
Cortical erosion	5	0	1	1	1	0	8
Cystic changes	5	1	7	0	0	1	14
Associated findings	8	1	6	1	0	0	16
Osteoporosis	7	0	1	1	0	0	9
Narrowed joint space	4	1	6	1	0	0	12
Hypertrophic lipping	4	1	0	0	0	0	5

* Includes one erroneous impression in which an entirely extra-articular lesion was interpreted as being both intra-articular and extra-articular.



FIG. 1. Prominent expansion of suprapatellar recess and exuberant synovitis are seen along anterior convexity of femoral condyles, indicating intra-articular involvement. Although appearance is not specific, prominence of synovitis should bring to mind possibility of pigmented villonodular synovitis.

up an error in one instance in which superimposition of an entirely extra-articular lesion simulated intra-articular involvement (Fig. 3, *a* and *b*). The intra-articular manifestations of synovitis consisted of visualization of synovitis within the confines of the joint in 18 instances and expansion of the synovial sac in 17. Particularly in the lesions with apparent extra-articular involvement, but also in others, the soft-tissue manifestations could be further characterized as tumefactive in 10 instances, lobular in outline in 9, and varying somewhat in density in 5. Soft-tissue evaluation of the 4 circumscribed lesions of the knee was negative in 2 instances; of the 2 lesions with positive findings, 1 showed expansion of the suprapatellar recess, which was later proved to be due to fibrinous exudation, and the other lesion revealed tumefaction, which appeared to be, and was also proved to be, extra-articular.

Soft-tissue abnormality was not recognized in any of the lesions of the hip or in the lesion of the shoulder. The lesion of the ankle exhibited lobular tumefaction adjacent to the posterior tibiotalar articular surfaces, with an indefinite capsular relationship. The lesion of the wrist (Fig. 4, *a* and *b*), which also demonstrated an indefinite articular capsular relationship, revealed lobular tumefaction surrounding the carpus. The origin of this extensive lesion was uncertain, because at operation it was found to involve the carpal joints as well as the adjacent flexor and extensor tendons.

Calcification was not found in any of the lesions. One unusual and striking diffuse lesion of the knee (Fig. 5) exhibited ill-defined variations of increased density within a large suprapatellar lobular tumefaction; this was originally thought to represent calcification within a synovioma. A roentgenogram of the surgical specimen (Fig. 6) confirmed the pattern of abnormal density, but microscopic examination of



FIG. 2. Intra-articular synovitis and two lobular soft-tissue tumefactions are seen in popliteal region outside normal confines of synovial sac, indicating extra-articular involvement. A small sub-cortical cyst is visible in medial femoral condyle anteriorly.

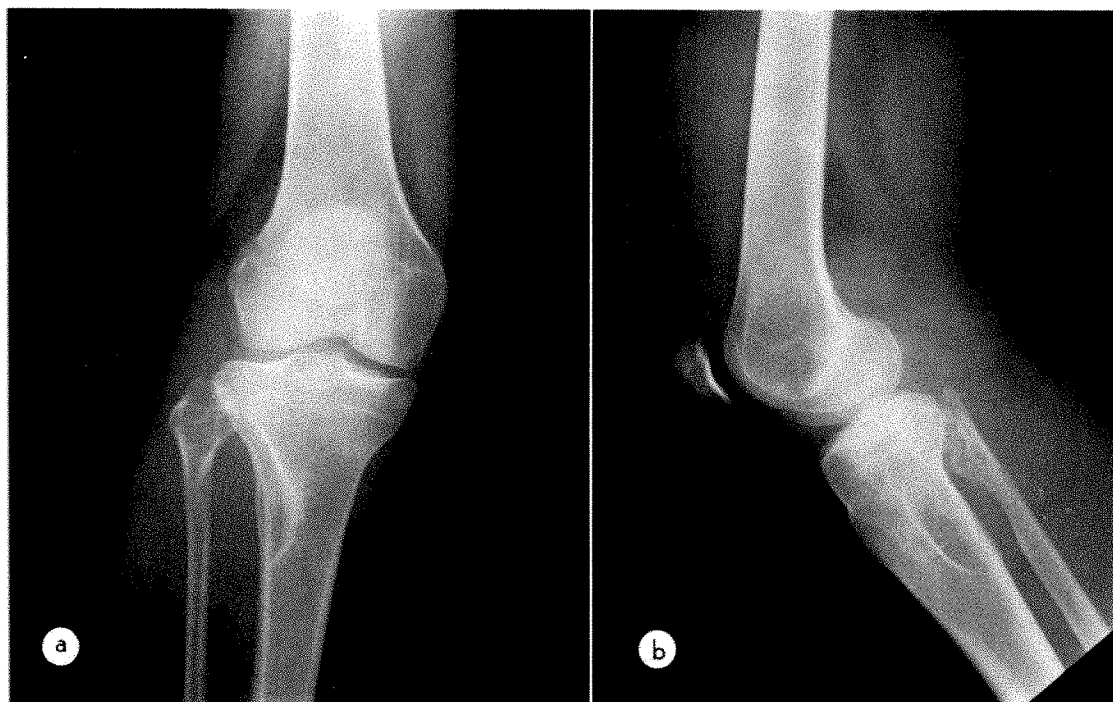


FIG. 3. (*a* and *b*) Lobular tumefactions are present in popliteal region and along lateral aspect of knee. Although involvement appears to be both extra-articular and intra-articular, lesion was proved to be entirely extra-articular. Shallow pressure-erosion of proximal shafts of tibia and fibula and excavation of head of fibula are seen, giving the latter a cystic appearance. (*a* reproduced with permission from *Am. J. Clin. Path.*¹³)

tissue sections from the dense areas stained for iron disclosed intense concentrations of iron. Sections stained for calcium were negative.

Local Osseous Changes. Local osseous changes directly attributable to the pathologic process were not specific but appeared to complement soft-tissue changes with respect to function and anatomy. Cortical erosion with irregularity or dissolution of articular and juxta-articular surfaces, seemingly the result of pressure or invasion by the abnormal tissue, was occasionally observed. In general, this type of reaction was superficial, but relatively deep erosion with alarming irregular cortical destruction was seen in 2 extensive diffuse lesions of the knee and had been verified at operation (Fig. 7, *a* and *b*; 8; and 9, *a* and *b*). Occasionally, cyst-like osseous lesions were noted which appeared to be the result of excavation by local synovial thickening (Fig. 3, *a* and *b*; and 4, *a* and *b*). A few small, entirely subcortical cysts which

tended to have thin sclerotic margins and to be loculated were also visualized (Fig. 2), but when they were unroofed, their content revealed fibrinous and myxomatous tissue of the type that occurs frequently in association with degenerative joint disease.

Of the 24 diffuse lesions of the knee, 8 exhibited localized osseous changes involving, in 7 instances, the vicinity of the patellofemoral articulation. Cortical erosion affecting the anterior femoral articular surface was noted in 5 instances, and cystic changes apparently due to excavation involved the articular surface of the patella in 3 instances. One patella was nearly completely destroyed by excavation (Fig. 7, *a* and *b*). One slowly expanding extra-articular interosseous lesion produced shallow pressure-erosion of the proximal shafts of the tibia and fibula, and it caused excavation of the head of the fibula, giving the bone a cystic appearance (Fig. 3, *a* and *b*). Solitary subcortical cysts of the medial femoral condyle were seen in 2 cases; one

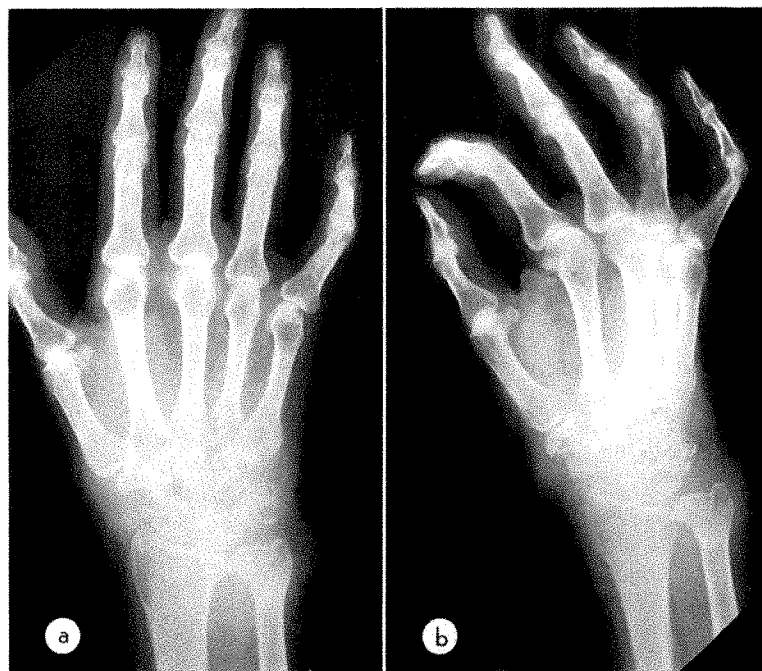


FIG. 4. (*a* and *b*) Lobular synovial tumefaction surrounds carpus. Cystic changes are present in all carpal bones, in bases of some metacarpals, and in distal ends of radius and ulna. In some carpal bones cystic changes have a punched-out appearance somewhat suggestive of lesions of gout. Despite extensive involvement of wrist, bones of hand are not osteoporotic.

of these represented the only instance of a circumscribed lesion associated with an osseous finding, since all the other osseous changes were caused by diffuse synovial involvement.



Each of the 7 lesions of the hip exhibited cystic changes; the cysts were usually associated with sclerotic margins, and they ranged from a few millimeters to 2 cm. in diameter (Fig. 1c). The femoral head or neck was involved in every case; the acetabulum was involved in 5 cases. In 2 instances the cysts of the femoral head appeared to have resulted from excavation, but roentgenographic differentiation of this type of cyst from subcortical cysts was not always possible. Cortical erosion was visible in one lesion in which much of the femoral and part of the acetabular articular surface was gone.



FIG. 5. Massive lobular soft-tissue tumefactions are present in popliteal and suprapatellar regions; they vary in density, especially just above patella, where appearance suggests calcification. Bones appear normal except for small exostotic cortical spicule along medial aspect of femur. Over-all appearance is strongly suggestive of articular pigmented villonodular synovitis, although increased density due to intense concentration of iron may be misleading.



FIG. 6. Roentgenogram of surgical specimen from same case as in Figure 5 confirms abnormal density pattern. Stains of tissue sections from dense areas were negative for calcium and strongly positive for iron.



FIG. 8. Roentgenogram of operative specimen from case of Figure 7 better illustrates osseous changes and emphasizes varying density of soft-tissue tumefactions.

The lesion of the wrist (Fig. 4, *a* and *b*) was unique in that cystic changes, predominantly of the excavating type, were seen in nearly all of the carpal bones and to a lesser extent in the bases of several meta-



FIG. 7. (*a* and *b*) Huge lobular tumefactions surround knee. Joint space is narrowed and erosion of bone has resulted in destruction of much of distal end of femur and has nearly completely destroyed patella.

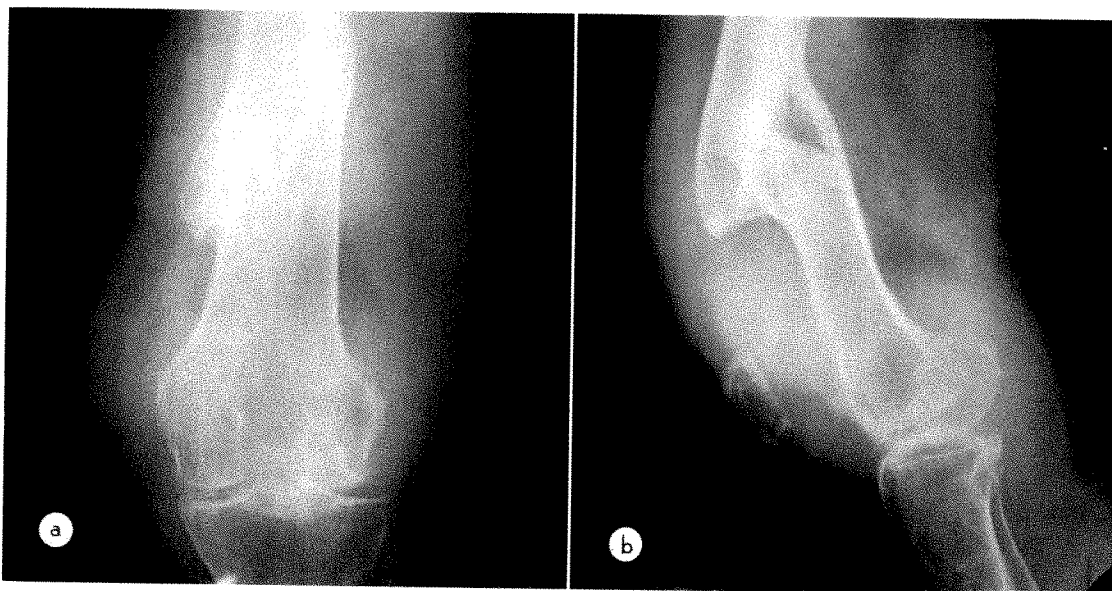


FIG. 9. (*a* and *b*) Massive synovial tumefaction is present which has a lobular outline and nearly completely surrounds knee. Articular aspect of patella appears cystic and anterior articular surface of the femur is irregularly destroyed by erosion. This appearance might be mistaken for that of a synovioma.

carpal bones and the distal ends of the radius and ulna. The lesion of the ankle

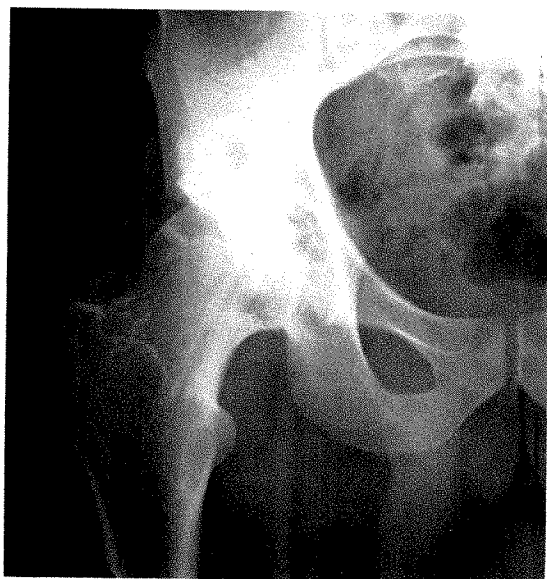


FIG. 10. Prominent cystic changes with sclerotic margins are seen in femoral neck and acetabulum. Moderate narrowing of the joint space is present. No soft-tissue abnormality can be identified. Prominent cystic changes with relative absence of other stigmata of degenerative joint disease should bring possibility of pigmented villonodular synovitis to mind. (Reproduced with permission from *Proc. Staff Meet., Mayo Clin.*⁸)

exhibited irregular cortical erosion of the tibiotalar articular surfaces laterally, with pressure erosion of the adjacent fibula. The lesion of the shoulder showed minimal erosion of the articular cortex adjacent to the greater tuberosity of the humerus.

Other Associated Findings. Osteoporosis was uncommon; in fact, its absence was sometimes surprising (Fig. 4, *a* and *b*). When present it was unimpressive except in the lesion of the ankle. Moderate osteoporosis was observed in the lesion of the hip associated with articular cortical erosion and, in one lesion of the knee in which a superimposed fracture of the femoral shaft had occurred, with subsequent malunion. Six other lesions of the knee exhibited slight osteoporosis.

Hypertrophic lipping was conspicuous by its frequent absence; it was detected in only 5 lesions of the knee and was of slight degree. Narrowing of a joint space, reflecting degeneration of articular cartilage, could be recognized in 5 tibiofemoral articulations and in one patellofemoral articulation. It was moderate or pronounced in 6 of the 7 lesions of the hip. Sclerosis was uncommon except when associated with cystic changes of the hip. Two lesions of

the knee exhibited small exostotic cortical spicules arising from the medial distal femoral shaft in one instance and from the medial proximal tibial shaft in the other. One of these lesions was associated with overlying synovial masses (Fig. 5).

DIFFERENTIAL DIAGNOSIS

Objective roentgenographic differentiation of articular pigmented villonodular synovitis from various types of arthritis or other lesions of the joint approaches feasibility only in extensive lesions. Ancillary clinical information is almost invariably necessary in arriving at the correct interpretation. It may be exceedingly difficult to differentiate even extensive lesions from tuberculous arthritis. In the absence of the conspicuous osteoporosis, marginal articular cortical destruction, or sequestration usually associated with massive tuberculous synovitis, differentiation depends on clinical investigation.

In its most characteristic lobular and tumefactive form, articular pigmented villonodular synovitis still may be roentgenographically indistinguishable from synovial sarcoma. Only the presence of dense, amorphous calcification rules out the former. Although cortical destruction is more characteristic of synovial sarcoma, it was detected in 2 lesions of the present series. Some reliance may be placed on the greater likelihood that synovial sarcomata will be extra-articular, but definite differentiation depends on biopsy.

COMMENT

Of course, unawareness of the existence and nature of this disease process precludes that even the most astute and perceptive observer will arrive at the proper diagnosis. However, the problem at hand was to determine whether or not objective roentgenographic analysis, alone or in combination with ancillary clinical information, can suggest, strongly indicate, or pinpoint the diagnosis.

A pathognomonic appearance of articular pigmented villonodular synovitis was not found in the reports from the literature or

in the analysis of the present series. On the other hand, the results of roentgenographic examination for this condition are seldom entirely negative. The role of roentgenography rests on the middle ground.

Depending on the extent, location, and gross pathology of the lesion, objective roentgenographic analysis will show soft-tissue changes in as many as two-thirds of the cases and local osseous changes in about half of the cases. The local osseous changes are nonspecific and may resemble changes associated with a variety of conditions. They consist of superficial erosions and cystic changes, and even these often are not outstanding features of this disease, except for the frequent occurrence of cystic changes about the hip. Exceptionally, in very extensive lesions, moderate cortical destruction may occur, and this may mislead the roentgenologist into making an erroneous diagnosis of synovioma.

Only in a minority of the cases involving the knee—namely, in those lesions of the diffuse type in which the synovitis appears unusually abundant and features of other conditions are absent—can it be expected that articular pigmented villonodular synovitis will come to mind. A few cases will exhibit massive noncalcified synovial tumefactions arising intra-articularly, having a lobular outline, and varying in density. This appearance could hardly indicate any other disease process, but it is insufficiently distinctive to be diagnostic. In any stages of this condition, ancillary clinical information may more readily bring to mind or strengthen the impression, but precise differentiation depends on examination of the tissue.

As might be expected, the roentgenographic findings associated with the circumscribed type of lesion are fewer and less specific. Occasionally, a soft-tissue mass or effusion, and, rarely, a nonspecific osseous change can be identified.

Insufficient information was found concerning the role of pneumoarthrography in the diagnosis of this condition. One of six such studies reported in the literature pinpointed the correct diagnosis, but the ac-

curacy and validity of this examination remain to be determined.

SUMMARY AND CONCLUSIONS

Articular pigmented villonodular synovitis is an accepted nonmalignant disease entity of controversial origin and nature. For all practical purposes, the involvement may be considered monoarticular. The condition occurs intra-articularly as a diffuse or focal lesion; rarely there is an extra-articular component. From the English literature and the present series, 202 cases have been found in which the large joints were involved. There is an overwhelming predilection for involvement of the lower extremity, particularly the knee. The disorder occurs most commonly in young adults, affecting females somewhat more frequently than males. The typical clinical course consists of progressive and painful swelling of the involved joint, with occasional exacerbations. Laboratory studies are usually unremarkable except for the frequently serosanguineous nature of aspirated fluid, which may be high in cholesterol content.

The roentgenographic manifestations of this condition are usually nonspecific and consist of synovitis with occasional superficial osseous erosion and cystic changes, depending on the location and gross pathology of the lesion. In a less common but more distinct form, some extensive diffuse lesions of the knee may show exuberant, noncalcified synovial tumefactions which vary in density and have a lobular outline. Frequently, lesions of the hip may exhibit exaggerated cystic changes. Although these appearances may suggest the correct diagnosis with reasonable accuracy, the precise diagnosis depends on examination of the tissue.

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POSTRADIATION OSTEOGENIC SARCOMA*

REPORT OF A CASE AND REVIEW OF LITERATURE

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NEW YORK, NEW YORK

THE development of postradiation sarcoma is an exceedingly rare complication of any form of modern radiation therapy. To the best of our knowledge, pelvic osteogenic sarcoma developing after the combined use of an internal radium system and external radiation therapy in the treatment of carcinoma of the cervix has not been previously reported in the literature. It is the purpose of this paper to describe a case of Stage I carcinoma of the cervix treated with the usual dose of radium and external radiation therapy which developed an osteogenic sarcoma of the ischial bone 14 years later. The entire subject of postradiation osteogenic sarcoma will be discussed in light of the previously described clinical, experimental and pathologic data gathered in the literature.

REPORT OF A CASE

C.B. (MSH No. 96093), a 68 year old white female, was admitted with a 6 month history of pain in the left hip radiating along the antero-lateral aspect of the left lower extremity to the toes. The pain was constant and progressive. There was weakness of the left leg.

Fourteen years previously, the patient had a Stage I carcinoma of the cervix. The lesion was small and freely movable, occupying the left aspect of the portio vaginalis of the cervix. The patient received 1,200 r skin dose through both anterior and posterior 10×15 cm. pelvic fields at 80 cm. target skin distance, followed by 2,000 r over anterior 4 cm. wide split field and 1,800 r over posterior 4 cm. wide split field (200 kvp., half value layer 0.9 mm. Cu). In addition, she received 4,050 mg.hr. radium treatment from a vaginal colpostat loaded with two 25 mg. tubes and 3,645 mg.hr. from an intrauterine tandem loaded with three 15 mg. tubes. The over-all treatment period lasted 57 days.

The calculated dose from the radium system at point B (near the lateral wall of the pelvis)

was 2,000 r. The contribution from the pelvic fields of external radiation was approximately 2,700 r, giving a total midpelvic dose of 4,700 r.

Five months after the completion of radiation therapy, the patient developed persistent diarrhea and tenesmus. The severe proctitis did not respond to the usual forms of therapy. A rectovaginal fistula then developed with negative biopsies for tumor. Because of the persistence of the fistula and the severe proctitis, a diverting colostomy was performed.

The patient was well for 13 years, after which time she presented with the symptoms which led to her last hospital admission.

Physical examination revealed a chronically ill patient in acute pain and a tender mass in the left parametrium fixed to the lateral pelvic wall. There was no evidence of recurrence of the carcinoma in the cervix or vagina. The rectal ampulla was markedly narrowed. Neurologic examination disclosed a foot drop on the left. There was weakness of all muscle groups in the left lower extremity as well as hypesthesia and absent position sense in the foot. The left ankle and knee jerks were absent. The hemoglobin was 8.0 gm. per cent and the alkaline phosphatase was 83 units. All other laboratory data were within normal limits.

A Turkel biopsy of the left ischium revealed osteogenic sarcoma. Because of the intense pain in the left lower extremity, a high dorsal cordotomy was performed with partial pain relief. The patient's condition quickly deteriorated and she died a few weeks after admission.

Roentgen Studies: The pelvic bones during a barium enema examination in 1957 (Fig. 1) showed no abnormalities. Chest roentgenograms at that time were also normal.

Examination of the pelvis in August, 1959 demonstrated an irregularly mottled calcific mass adjacent to the medial aspect of the left ischium. On the frontal roentgenogram (Fig. 2) it was noted to overlies the acetabulum and to extend superiorly to the upper third of the pelvic brim; its inferior limit was the ischial tuberosity. Medially, the mass projected 4 cm.

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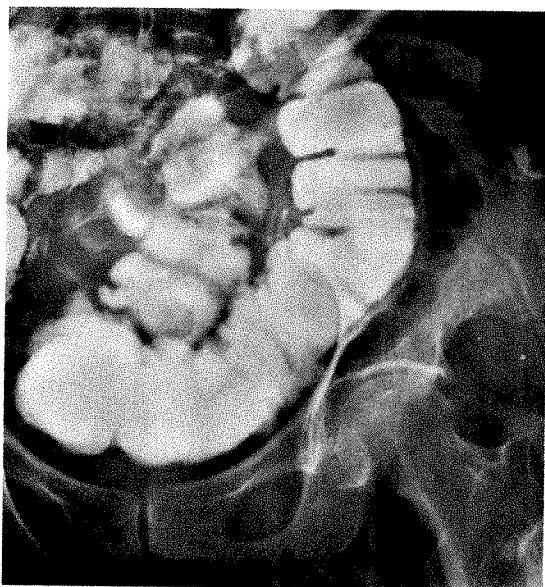


FIG. 1. The pelvic bones were noted to be normal on a barium enema study performed in 1957.

into the pelvic cavity and laterally it extended to the intertrochanteric line of the femur. The cortex of the posterior border of the ischium and lower ilium was destroyed (Fig. 3). Profuse

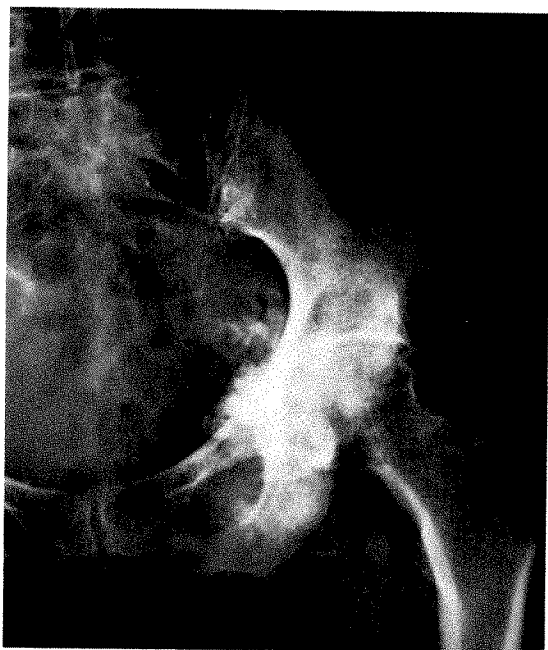


FIG. 2. In 1959, there was an irregularly mottled calcified mass involving the medial aspect of the left ischium and extending into the left side of the pelvic cavity.

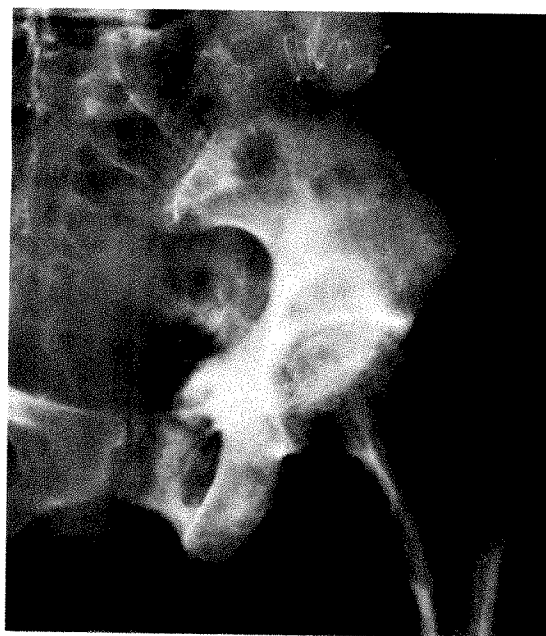


FIG. 3. In the oblique projection, the cortical border of the ischium was seen to be destroyed posteriorly by the calcified neoplasm. Profuse periosteal new bone formation was noted in the involved area.

periosteal new bone formation extended from the involved bone into a poorly demarcated soft tissue mass measuring 10×6 cm. This contained numerous irregularly mottled and striated areas of calcification. The medullary cavity of the pelvic bones was denser than normal but contained no discrete areas of destruction.

The chest roentgenogram now revealed a dense, well-circumscribed mass overlying the inferior portion of the left lung root (Fig. 4). Bucky roentgenograms and laminagraphic studies demonstrated a densely calcified mass, the size of a plum, with an inferior tongue-like projection (Fig. 5). It was situated in the posterior mediastinum but did not involve any of the contiguous ribs or vertebrae. In the left upper lung field, there were at least two sharply demarcated, partially calcified, scalloped densities along the lateral chest wall, extending to the apex of the thoracic cage (Fig. 4). Numerous poorly margined nodular densities up to 1 cm. were scattered throughout both lung fields.

DISCUSSION

The method of treatment and the dose of radiation administered to this Stage I carcinoma of the cervix are generally accepted

as being effective and safe. In all the other cases of carcinoma of the cervix treated at the Mount Sinai Hospital with such high dose of radiation, no similar severe rectal reactions leading to fistulization have been noted. This may reflect an unusual sensitivity of this patient's tissues to irradiation. It is very unlikely that a poor application of the uterine tandem and vaginal colpostat played a part in the development of the rectal fistula and pelvic neoplasm because no immediate proctitis was noted to suggest an overdose in the rectal region.

A dose of 4,700 r to point B was delivered over 57 days over-all treatment period. This long protraction may have been instrumental in the development of the severe late radiation reaction.

Postradiation malignant changes have been described and studied thoroughly from both the experimental and clinical aspects. However, the number of well documented osteogenic sarcomas developing in previously irradiated tissue has been noted to be small. The first such case occurred in a patient whose tuberculous bone was treated

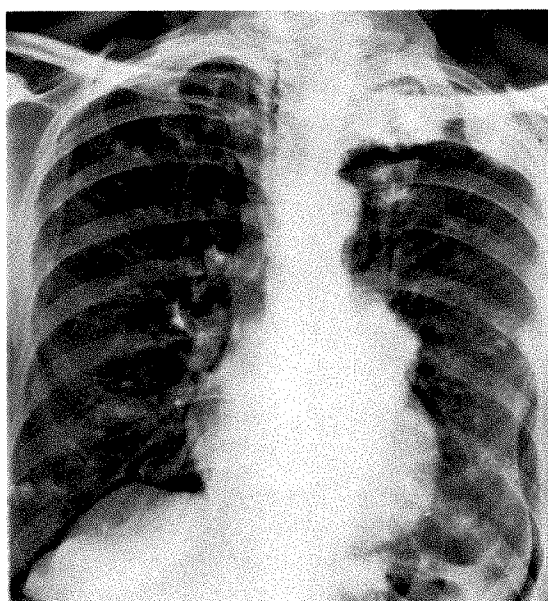


FIG. 4. Chest roentgenogram at this time revealed a well-circumscribed tumor mass at the left lung root. Scalloped densities were seen in the left upper lobe and numerous small nodular densities were noted in both lung fields.

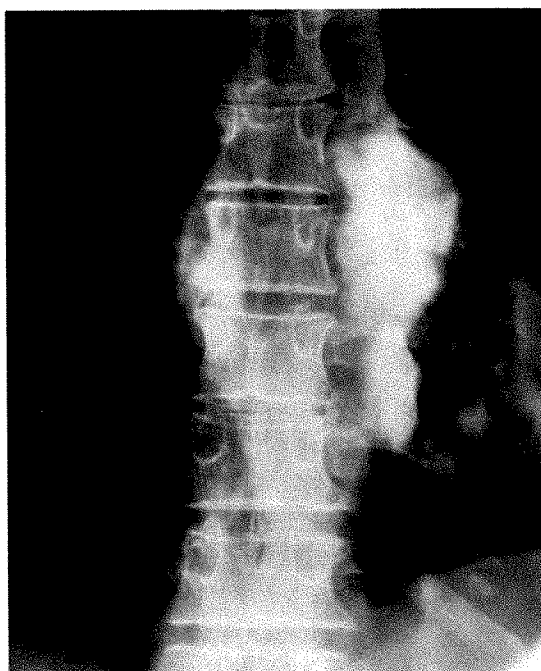


FIG. 5. Bucky view of the left root mass revealed that it was densely calcified and well-circumscribed.

with radiation and was reported by Beck and Marsch in 1922.

The long latent period, the development of an osteogenic sarcoma within a heavily irradiated volume of tissue in a bone which was formerly shown to be normal, and the unusual location for a spontaneously occurring osteosarcoma are all features of this case which conform to Cahan and co-workers's definition of a postradiation osteogenic sarcoma.

In 1948, Cahan *et al.*⁸ reviewed the 17 cases previously described in the literature and added 11 of their own. They established the following criteria for the diagnosis of a postradiation osteogenic sarcoma: (1) that the sarcoma must have arisen in irradiated bone; (2) that microscopic or roentgen evidence must be available of the nonmalignant appearance of the affected bone before irradiation; (3) that a relatively long, silent, latent period must exist; and (4) that all the sarcomas must be histologically proven.

In most of the previously reported cases, the sarcomas have arisen in an area of bone

containing either a benign tumor such as "giant cell tumors," or have been the seat of chronic osteomyelitis, tuberculous process or pyogenic disease.^{8,15,17,22}

In other instances, the bone was normal and was merely included within the field of irradiation; as in the case of the mandible in the treatment of cancer of the oral cavity, usually with interstitial radium, and the chest wall in the therapy of carcinoma of the breast.^{15,17,18,22}

Carroll *et al.*⁹ described an osteogenic sarcoma arising in the distal phalanx of a dentist with radiodermatitis as a result of holding dental films in place during exposure for many years. The dermatitis was treated with courses of 100 kv. radiation, 2 years apart. DeYoung¹³ described a patient who was given 3,200 r and 3,600 r per week, 1 year apart, to the distal femur (details of the quality of radiation and of the dose are not available), in an attempt to slow down the growth of the femur at the distal epiphysis. An osteogenic sarcoma developed in this region 5 years after the initial course.

Spitz and Higinbotham²³ reported a case of an osteogenic sarcoma of the lumbar spine occurring in a man who had received "prophylactic irradiation" to the retroperitoneal region of a seminoma of the testis. The dose received in the tumor-bearing area was between 3,300 and 3,400 r over a 3 month period. There was a latent period of 4 years.

Auerbach *et al.*² described a case of soft tissue osteogenic sarcoma developing 4 years after retroperitoneal irradiation for testicular seminoma. A 4,000 r skin dose was delivered in 70 days. Blumberg and Hufner⁴ reported 4 cases of postradiation sarcomas in a total of 250 patients with seminomas treated with postoperative radiation therapy to the retroperitoneum.

The thorough investigations of the osteogenic sarcomas occurring in luminous dial workers, as a result of radium poisoning, have shed much light on the pathogenesis of radiation sarcomas.

Aub *et al.*¹ carefully studied and de-

scribed 30 patients exposed to internal radioactivity for at least 25 years. The changes found in the bones were of two types: first were the alterations of the bony architecture of a nonneoplastic nature, called "radiation osteitis" by Markland;²⁰ second were the malignant changes in the irradiated bone.

Three histologic stages of radiation osteitis can be recognized. The earliest changes are those of a hyperplastic, irritative bone marrow, brought about by the stimulation of the hematopoietic centers within the marrow. Later, there is a replacement of this hyperplastic marrow by a severe fibrosis. The last stage is a completely aplastic, acellular marrow. Roentgenographically, one first recognizes coarsening and irregularity of the trabecular pattern. Gradually expanding, irregular areas of rarefaction then develop within the medulla and finally, numerous densely sclerotic islands arise within the affected areas.

In Aub and co-workers'¹ 30 patients, there were 8 cases of malignancy in the skeleton. These included 3 osteogenic sarcomas, 1 giant cell sarcoma, 1 fibrosarcoma and 3 epidermoid carcinomas (of the accessory nasal sinuses). The average latent period in these cases was 23 years. This figure is slightly higher than that given for osteosarcomas developing after external radiation. Sabanas and his colleagues'²² 17 cases had an average latent period of 10 years, ranging from 32 months to 30 years. Cahan *et al.*,⁸ who used the end of radiation therapy to the onset of symptoms as the latent period, gave a range of 5 to 22 years. It was often difficult to determine the precise length of the latent period because radiation therapy was administered over many years. Such was the case in one of Wolfe and Platt's²⁵ patients who received radiation therapy off and on during 19 years.

The lowest dose of external irradiation to bone which has been thought to have produced an osteogenic sarcoma is 3,000 r.¹⁷ Most of the other reported cases have received a larger dose; namely, between

4,000 and 7,500 r. Cade's⁷ 2 patients were given 7,700 r and 8,800 r, respectively. It must be emphasized that, especially in the cases reported early in the literature, only few details are available as to the quality of radiation, the over-all treatment time or the depth in tissues where a given dose was measured.

Evans⁶ has estimated that at least 7,000 reps over a 10 year period are necessary to produce a malignancy, when minimal quantities of radioactive materials are deposited within bone. On the other hand, Finkel *et al.* found that the probability of developing an osteogenic sarcoma increased with the dose absorbed until a certain "indifferent dose" was given.

Woodard and Coley²⁶ investigated the relationship between the dose of radiation and the degree of bone regeneration and growth in 22 patients who were treated for various conditions in either 1, 2, or 3 courses. The degree of bone regeneration was estimated by the extent of restoration of the integrity and structure of the trabeculae and by the amount of mineralization present. There was no evidence of any bone damage up to doses of 3,000 r. From 3,500 to 4,500 r transient and often minimal changes were noted, such as mild demineralization and inability of the bone to repair damages of ordinary use. Severe damage and irreversible changes resulting in bone death occurred between 5,000 and 8,000 r.

Postradiation fractures of the neck of the femur are a well-known complication of radiation therapy to the pelvis. They are especially frequent when lateral and oblique pelvic portals are used as for bladder or cervical cancers. Pathologically, the most striking change is a zone of subcapital demineralization at the fracture site.⁵ This may represent aseptic necrosis of bone secondary to an obliterative vascular factor in the pelvic vessels brought about by the radiation. Furthermore, as osteoblasts are known to be more sensitive to radiation than osteoclasts, a temporary inactivation of bone regeneration occurs.¹⁶

The salient differences between the development of femoral neck fractures and the occurrence of pelvic osteosarcoma following radiation therapy for carcinoma of the cervix are the doses involved, the length of the latent period intervening, and the frequency of occurrence. Postradiation femoral neck fractures usually develop as early as 5 months after 3,000 to 3,500 r exposure to the femoral neck. A few cases are reported in every large series of carcinoma of the cervix treated by radiation.¹⁰ On the other hand, as in the case reported here, a long latent period of about 14 years exists between irradiation and occurrence of osteogenic sarcoma. The dose delivered is usually above 4,500 r. In none of the well documented series of carcinoma of the cervix treated by radiation therapy reviewed in the literature has a single similar case been found.

The stages in the pathogenesis of post-radiation osteogenic sarcoma remain obscure. The relationship between the non-malignant postradiation bone changes and the development of osteogenic sarcoma is also unknown. As early as 1936, Ross¹⁷ was able to induce osteosarcomas with low-intensity radium tubes implanted in the periosteum of rats. Dunlap *et al.*¹⁴ produced osteogenic sarcomas after internal administration of radium in rats. They found numerous areas of atypical bone formation within segments of nonmalignant osteitis. From both their experimental findings and their clinical experiences with radium-induced sarcomas, they suggested that the malignancy arose from partially frustrated attempts to regenerate bone in regions of radium necrosis. Martland's²⁰ finding that all of his 5 cases of osteogenic sarcoma in radium dial workers were preceded by radiation osteitis supports the same theory. Heller⁶ pointed out that, in experimental animals, the oldest portion of the sarcoma was adjacent to devitalized spongiosa—an area in close proximity to continued substantial radioactivity.

On the other hand, Jones¹⁷ stressed the differences in both the clinical and patho-

logic findings of radiation osteitis and post-radiation osteogenic sarcoma. He emphasized that in none of his cases of osteosarcoma could he find any evidence of osteonecrosis and therefore concluded that different factors were involved in their production.

SUMMARY

A case of pelvic osteogenic sarcoma is presented, occurring 14 years after radiation therapy for Stage I carcinoma of the cervix. No previous similar case has been described in the vast literature on radiation treatment for carcinoma of the cervix. The clinical and experimental literature on post-radiation osteosarcoma is reviewed.

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EDITORIALS

THE FORTY-FOURTH ANNUAL MEETING OF THE AMERICAN RADIUM SOCIETY

THE American Radium Society held its Forty-fourth Annual Meeting in New York City on April 2, 3 and 4, 1962 at the Waldorf Astoria Hotel. The attendance of members and guests exceeded that of the 1961 meeting with a total registration of 520, representing 174 members, 241 non-member guests and 105 ladies. On Sunday evening prior to the meeting, many of the New Yorkers entertained the outside members in their homes. The membership expressed its appreciation for this warm display of hospitality. Later, the same evening, provision was made for attendance at a most enjoyable "Off-Broadway" Theater Party in lower Manhattan.

The meeting was officially opened on April 2 in the Astor Gallery when the Society was welcomed by Dr. Lemuel Bowden, Chairman of the Arrangements Committee. Dr. Robert L. Brown delivered the Presidential Address in which he redefined the objectives of the American Radium Society. He pointed out that, when the Society was formally organized 46 years ago in Philadelphia, the founding group included 10 surgeons, 5 radiologists, 3 dermatologists, 1 internist and 1 physicist. The first president was a Canadian internist. Thus, from the very beginning the American Radium Society has included in its membership representatives from various specialties and the membership was international. Today, a greater variety of specialists comprises its membership and 21 different countries are represented. The common denominator has always been the study of malignant disease and the agents most effective in its management, with particular attention to radium, roentgen rays and other sources of ionizing radia-

tions. Dr. Brown stated that only two changes have been made regarding the objectives since the original constitution was written. The original constitution stated that the object of the Society was to promote the scientific study of radium in relation to its physical properties and its therapeutic application. The first change came in 1950 with the inclusion of other ionizing radiations and last year a further change was made to include biologic effects and to encourage liaison between the various specialties concerned with the treatment of cancer. He stated that, although the future of cancer therapy may belong to the biochemist and the immunologist, surgery and irradiation are the most effective agents now at our disposal for the treatment of cancer.

The first scientific session under the chairmanship of Dr. Joseph H. Farrow consisted of presentations on the management of carcinoma of the bladder with supervoltage irradiation, 3 to 5 year survivals in cases of nasopharyngeal tumors with 2 mev. therapy and radiotherapy in the treatment of primary operable carcinoma of the breast with proved lymph node metastases. Dr. Ruth J. Guttmann pointed out that certain patients with breast carcinoma, according to the original criteria of Haagensen and Stout, were considered "operable carcinomas." Now, the group of patients with positive high axillary and/or internal mammary lymph nodes are considered inoperable and are subjected to radiotherapy. A dose of 5,000 rads with 2 mev. in 5 weeks plus an additional 2,000 rads with orthovoltage technique produced 50 per cent 5 year survivals and 41 per cent 7 year survivals in a series of

111 patients treated. Dr. J. R. Heller, President of the Sloan-Kettering Cancer Center, presented his thoughts on "Clinical Trials in the Next Decade" in relation to research. The factors of population, random assignment and controls, criteria of evaluation, follow-up procedures and size of population studies would determine whether or not various methods of treatment of cancer used singly or in combination would be successful.

Following the morning coffee break, a Symposium on the management of certain "solid" tumors of childhood was moderated by Dr. Harold W. Dargeon. Neuroblastoma as treated by radiation and surgery was discussed by Dr. Joseph Fortner and Dr. Ralph F. Phillips.

Dr. Charlotte Tan presented the effects of the actinomycins, cytoxan and methotrexate used alone and in combinations with radiation. Wilms' tumor was considered by Dr. Elizabeth Pickett, Dr. Ralph F. Phillips and Dr. Charlotte Tan from the standpoint of surgery, pre- and postoperative irradiation and the effects of added actinomycin. The late effects of roentgen therapy of neuroblastoma and Wilms' tumor were discussed by Dr. G. J. D'Angio and Dr. Brian O'Malley.

Dr. Gilbert H. Fletcher was chairman of the second scientific session at which a variety of subjects was presented. Dr. Paul C. Aebersold of the United States Atomic Energy Commission disclosed that new techniques were being devised to develop new isotopes and to improve quantity production of known isotopes at a considerable lower cost. One of the highlights of the meeting was the presentation on modern techniques of treatment of cancer of the accessory nasal sinuses by Professor Sir Brian W. Windeyer of the Middlesex Hospital in London, who stated that as compared to treatment with orthovoltage radiation in previous years, the use of cobalt 60 and the linear accelerator has produced better results in these cases. Nasopharyngeal fibromas can now be controlled with a dose of 8,000 rads in a period of 8

weeks. A Symposium on supervoltage therapy followed relating the effects of the synchrotron, linear accelerator, betatron, cobalt 60 and 2 million volt roentgen rays. Dr. J. W. J. Carpender was moderator and the participants were Drs. Robert Stone, Professor Sir Brian W. Windeyer, John Boland, Nora duV. Tapley and Edwin Liebner. In other papers of the afternoon session, a comprehensive implant dosimetry system and a short axis rotation technique with cobalt 60 teletherapy unit using wedge filters and square fields were described.

The third scientific session began on Tuesday morning with Dr. Ralph F. Phillips acting as chairman. Dr. Robert D. Sullivan of the Lahey Clinic presented material on the effects of prolonged intravenous and intra-arterial infusion of cancer chemotherapeutic compounds. Dr. R. Lee Clark, Director of the M. D. Anderson Hospital and Tumor Institute in Houston, Texas, outlined the clinical significance of recent progress in cancer research. He stated that the progress made over the past two decades exceeded that of the previous two centuries. Dr. Roberts Rugh presented further studies on low dose x-ray effect on the mammalian embryo and fetus. Following a short coffee break, Dr. William S. MacComb moderated a panel discussion on the management of carcinoma of the larynx. Drs. Clifford L. Ash, Glenn H. Leak, Daniel Catlin and Philip Rubin participated in the discussion and differences of opinion were expressed by surgeons and radiologists. A great deal of information was imparted to the audience by a presentation of a variety of problems.

In the latter part of the morning session, the Annual Janeway Lecture was given. Dr. Lloyd F. Craver introduced the speaker by reviewing some of her investigative work emphasizing research on thyroid cancer. He pointed out that 4 pathologists have been selected over the years as Janeway Lecturers, beginning with James Ewing in 1933, the first Janeway Lecturer, Francis Carter Wood in 1934, Arthur

Purdy Stout in 1952 and now Virginia Kneeland Frantz in 1962. Dr. Frantz spoke on "The Privileges and Challenges in the Study and Treatment of Thyroid Cancer." In a charming manner Dr. Frantz related some historical background at Columbia University in the early years of the study and development of classification of thyroid carcinoma. Examples of long term follow-up were cited and the various methods of surgical, chemical, hormonal and radiological therapy were outlined.

Dr. Charles G. Stetson was chairman of the fourth scientific session which opened with a presentation by Dr. George E. Moore, director of the Roswell Park Memorial Institute on the significance to radiologists of recent advances in cytology. He emphasized the value of various cytologic techniques which have made it possible to separate cells according to their chromosomal pattern. Many neoplasms have a grossly abnormal number of chromosomes. It is important to study the relationship of these karyotypes to radiation response. The participants were Professor Sir Brian W. Windeyer, Drs. George E. Moore, Henry S. Kaplan, Halvor Vermund, and G. J. D'Angio. The members of the panel cited their experiences with various types of drugs employed in conjunction with ionizing radiation. Some of the panelists warned against the indiscriminate use of these toxic agents by those not engaged in carefully controlled investigative work. Dr. Milton Friedman presented his experiences on the combined radiation and methotrexate treatment of squamous cell carcinoma of the mouth and pharynx. An interesting piece of experimental work was reported by Dr. Robert C. Hickey and his co-workers on the palliation treatment in human breast cancer by pituitary irradiation with focused ultrasound. The final paper of the afternoon session was given by Dr. John T. Goodner on the treatment of 8 cases of sarcoma of the esophagus at the New York Memorial Center from a series of 1,626 cases of cancer of the esophagus during the years 1926 through 1960.

Later in the evening, a reception was sponsored by the Radium Chemical Company of New York on the Sert Terrace of the Hotel preceding the Annual Banquet in the Sert Room. Following the introduction of members and wives at the speaker's table, Dr. Robert Brown, with appropriate ceremony, presented the Janeway Medal to Dr. Virginia Kneeland Frantz for her outstanding achievements. Members and guests were entertained by an accomplished pianist from the New York Philharmonic Orchestra and also participated in dancing during the evening.

The final and fifth scientific session under the direction of Dr. Ethlyn Trapp included papers on the management of adenocarcinoma of the cervix, the significance of vaginal metastases in endometrial cancer, radiotherapy of malignant tumors of the vagina, experiences with total body irradiation and the evaluation of radiation therapy and management of 50 cases of chordoma. Dr. Calvin T. Klopp was moderator of an interesting symposium on preoperative irradiation, the participating panelists being Drs. Gilbert H. Fletcher, Maus Stearns, Willet Whitmore, Francis Hanson and William Newman.

The Ladies' program on Monday included a tour of the United Nations Building and of lower Manhattan. Mrs. Milton Friedman performed as hostess at the luncheon in the U. N. Delegates Dining Room. On Tuesday, the Ladies attended a Fashion Show at B. Altman and Company with Mrs. Arthur Holleb acting as hostess.

The Forty-fourth Annual meeting of the American Radium Society proved to be successful not only in its large attendance, but in the quality of its scientific program and in the attraction of its social events. Dr. Robert L. Brown and his committees, especially the Committee on Arrangements under the chairmanship of Dr. Lemuel Bowden, deserve commendation for their efforts.

HARRY HAUSER, M.D.

10300 Carnegie Avenue
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MANOEL DE ABREU, M.D.
1892-1962

PROFESSOR Manoel de Abreu, teacher, scholar, philosopher, scientist, poet and mentor—a man of genius endowed with versatile aptitudes—died in the city of Rio Janeiro on the morning of January 30, 1962 of carcinoma of the lung. The end came suddenly and he died quietly, with

the same dignity that characterized his whole life.

The loss of this great pioneer represents a void in the medical world, especially in the field of radiology, for Manoel de Abreu was one of the last of an international group that established the founda-

tions of modern roentgenology. He was the inventor of photofluorography, which by many is called "abreugraphy" in his honor. This and works such as "Geometrical Formation of the Images" and "Vascular Radiology" brought him to the attention of the medical world.

De Abreu was born in São Paulo, Brazil, and he had his preliminary education at the American School and the Hydcroft College. In 1908 he entered the Medical School in Rio de Janeiro, where he was a brilliant student, showing glimpses of his precise intellectual mind as exemplified by his outstanding work on social hygiene, "Poor Nature." He received his M.D. degree in 1913.

In 1914 he went to Europe, arriving there during the tragic month of August. Probably impressed by the historic events when sacrifice, heroism and human fraternity were the general conception, he decided to temporarily put aside his studies on sociology and philosophy and to fully dedicate himself to scientific investigations. He began working with Dr. Gaston Lion in the Hôpital de la Pitié, Paris, and in its laboratories he made the first attempts to take pictures of the gastric mucous membrane with a small apparatus he invented.

In 1916, while associated with Dr. Gilbert at Hôtel Dieu, de Abreu was amazed to find that he had been invited to be the Chief of the Central Radiological Laboratories. Since many of the French radiologists had been called into the service, he was given an assignment of great responsibility. In his modesty he was awed by the confidence the experienced radiologists placed in his capabilities at such a youthful age.

He then went to Laennec Hospital, the center of specialized chest roentgenology. There he met Dr. Maingot, a man of great learning, and, while he acquired considerable knowledge, he realized that many undetermined details were "not seen" in the pictures. He decided to investigate the image formation and its anatomic and pathologic relationship, and soon presented

before the Société de radiologie médicale de Paris his famous work, "La densimétrie pulmonaire."

In 1922, de Abreu returned to Brazil. His interest in image formation became more intense and he spent nights drawing anatomic forms, then later simplifying them into geometric forms. In 1924, he published "Ensaio sobre uma Nova Radiologia Vascular," a work which typified his exacting nature.

Books, papers and conferences covering his contributions to Radiology appeared in the literature from 1924 to 1930. These were translated into German, French, English and Spanish. It was, however, the subject of chest roentgenology that always attracted him and he pursued his investigations zealously and untiringly. Finally, in 1936, a historic year in de Abreu's life, he discovered a new technique for chest examination—photofluorography. This discovery represents in modern times one of the important achievements in medicine and places the name of Manoel de Abreu among those of other great benefactors of mankind.

De Abreu did not cease his work when success came his way. He was convinced that because of his discovery he owed the scientific world a responsibility and began what might be called his "missionary journey." He published many books and articles in foreign and local journals, teaching the new approach to chest examination and presenting the first statistical results. It is consoling to know that he lived to see his process not only universally accepted but thousands of precious lives saved because of it.

The more idle interludes in Dr. de Abreu's scientifically fertile life were filled by some exquisite literary writings, ranging from meditations, "Meditações," to philosophical essays, "A luta contra o Universo,"—to a series of poems, among which "Não Ser," "Substância," "Poemas sem Realidade" and "Mensagem Etérea" are rare jewels of beauty and delicate expression of thought.

Many honors came to this most deserving man. Some of the medals awarded to him were: Chevalier, Légion d'Honneur (1918); Reconnaissance Française (1918); Gold Medal, American College of Chest Physicians (1950); Diplôme d'Honneur de l'Association Culturelle Franco-Italienne et Latine (1950); Gran Cruz da Ordem Sanitária (1954); Gold Medal "Mentor de Radiología Americana," Asociación Argentina de Radiología (1953); and Medalha Colegio Interamericano de Radiologia (1958). He was a member of the Radiological Societies of Brazil, Buenos Aires, Bogotá, Germany, Córdoba, Para-

guay, Cuba, México, Venezuela, Uruguay, Bolivia, Lisbon, and Chile, as well as of the Valenciana Literature Academy. That he was elected President of the II International Congress of the American College of Chest Physicians (1952), the International Union against Tuberculosis (1952), the III International Congress of Radiophotography (1958), and the American College of Chest Physicians in Rio de Janeiro is further evidence of the esteem accorded Dr. Manoel de Abreu throughout the world.

MARIO ALVES FILHO, M.D.



UNITED STATES ATOMIC ENERGY COMMISSION

ATOMIC ENERGY RESEARCH. LIFE AND PHYSICAL SCIENCES, REACTOR DEVELOPMENT, WASTE MANAGEMENT, 1961. A special report of the United States Atomic Energy Commission, December, 1961. For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price, \$2.25.

In the May, 1962 issue of the *JOURNAL*, the Annual Report to Congress of the Atomic Energy Commission for 1961 was reviewed. Dr. Glenn T. Seaborg, Nobel Laureate, who is the Chairman of the Commission, stated that soon a supplemental report would be presented encompassing the extensive involvement of colleges and universities in the Commission's program of fundamental research. This supplemental report now has been issued and gives a comprehensive summary of the more important advancements in the major areas of this Commission-sponsored fundamental research. It describes the accomplishments for the fiscal year that ended June 30, 1961.

Since the field of atomic energy research is so broad and involved, the increasing benefits derived from it cover an ever-widening spectrum as the versatility of the atom's inherent energy continues to amaze scientists and laymen alike.

The Report is divided into four major parts: I. Research in Medical and Life Sci-

ences; II. Research in Physical Science; III. Reactor Program Research; and IV. Waste Management Studies.

The more significant achievements are highlighted in the introductory sections preceding each of the four parts.

There are three appendices listing the following important items: 1. Major Research and Development Installations of the U. S. Atomic Energy Commission; 2. Background Information and Summary Report on Surveys for Project Chariot; and 3. Current AEC Unclassified Research Contracts in Physical, Biological and Medical Sciences.

Part One on Research in Medical and Life Sciences includes sections on radiation, medicine and agriculture, research on cancer, somatic effects of radiation, radiation protection and treatment genetics, molecular and cellular studies, chemical toxicity, health and instrumentation studies, environmental radiation service, and work on atmospheric radioactivity and fallout shelters.

A perusal of these sections as well as some of the other topics presented in the remaining three parts of the Report should prove of greatest value to all radiologists and physicians interested in basic atomic research and its rapid conversion into exploratory efforts for the development of practical applications.



NEWS ITEMS

AMERICAN RADIUM SOCIETY ELECTS NEW OFFICERS

At the Forty-fourth Annual Meeting of the American Radium Society held at the Waldorf-Astoria Hotel, April 2-4, 1962, the following officers were elected: President, Gilbert H. Fletcher, Houston, Tex.; President-Elect, Charles G. Stetson, Englewood, N. J.; 1st Vice-President, Jean Bouchard, Montreal, Can.; 2nd Vice-President, Lemuel Bowden, New York, N. Y.; Secretary, Justin J. Stein, Los Angeles, Calif.; and Treasurer, Joseph H. Farrow, New York, N. Y.

The Forty-fifth Annual Meeting of the Society will be held at the Mark Hopkins Hotel in San Francisco, California, April 1-4, 1963. Further information relative to this meeting may be obtained from the Chairman of the Committee on Arrangements, Jerome M. Vaeth, M.D., Department of Radiology, University of California Hospitals, San Francisco Medical Center, San Francisco 22, California.

NATIONAL CONFERENCE FOR RADIOLOGICAL HERITAGE

The Council for Radiological Heritage, founded as the Gas Tube Gang in 1956, plans a meeting during the convention of the American Medical Association in Chicago at the McCormick Place on June 24, 1962. In addition to perfecting its organization and adopting regulations and assignments for its work, the meeting will include a panel discussion of radiological heritage with a noted monitor as leader. The following program is contemplated: (1) Breakfast 7:30 to 9:00 A.M.; (2) panel discussion 9:30 A.M.; (3) luncheon 12:30; and (4) business meeting 2:00 P.M.

Those planning to attend, please make reservations with Dr. Edwin C. Ernst, Director, 3720 Washington Avenue, St. Louis 8, Missouri.

COURSE ON THE DIAGNOSTIC AND THERAPEUTIC USES OF RADIOIODINE

A course on the diagnostic and therapeutic uses of radioiodine will be given at the University of Texas Southwestern Medical School and Parkland Memorial Hospital from June 11 through 16, 1962. The faculty will consist of members of the Department of Radiology, and a Guest Lecturer, who will be James H. Christie, M.D., of Highland View Hospital and Western Reserve University School of Medicine, Cleveland, Ohio. Enrollment is limited to 12 trainees.

Further information and enrollment forms are available from Frederick J. Bonte, M.D., Professor and Chairman, Department of Radiology, University of Texas Southwestern Medical School, 5323 Harry Hines, Dallas 35, Texas.

GRADUATE PROGRAM IN RADIOLOGICAL PHYSICS AND BIOPHYSICS

Announcement is made annually of the graduate program in radiological physics and in biophysics offered in the Sloan-Kettering Division of the Cornell University Graduate School of Medical Sciences.

The radiological physics program leads to the M.S. degree and includes courses and training in radiation dosimetry, health physics, x-ray spectroscopy, medical applications of isotopes with associated dosimetry and metabolic studies, computer technology and application to medical problems, diagnostic and therapy x-ray physics, as well as selected courses in pertinent biological, chemical and mathematical topics. From one to two years of graduate work are required, depending on the courses already taken. A thesis is required and several laboratory projects are available for this purpose.

The biophysics program leads to the

Ph.D. degree and includes provision for graduate courses in pertinent subjects in physics, biochemistry, physiology, and biostatistics. The thesis is carried out in any of the laboratories in the Department of Biophysics with one of its faculty members. Information on research projects, faculty members, and details of the graduate program will be supplied on request. A few fellowships which cover tuition and maintenance are also available. Inquiries should be sent to the Department of Biophysics, Sloan-Kettering Division of Cornell University Graduate School of Medical Sciences, 410 East 68th Street, New York 21, New York.

IV WORLD CONGRESS OF CARDIOLOGY

The IV World Congress of Cardiology will be held in Mexico City from October 7 to 13, 1962.

The registration fee is \$40 for active members and \$20 for associate members.

For further information, please write to Dr. I. Costero, Secretary General of the Congress, Avenida Cuauhtémoc 300, México 7, D. F.

Hotel reservations may be made through the office of the Secretariat either directly or its official travel agencies, Mundus Tours de México and Viajes Internacionales Pegaso, Post Office Box 9170, México, D.F.



BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

ATLAS OF TUMOR PATHOLOGY. Section IX—Fascicle 33. TUMORS OF THE FEMALE SEX ORGANS. Part 2: TUMORS OF THE VULVA, VAGINA AND UTERUS. By Arthur T. Hertig, M.D., Shattuck Professor of Pathological Anatomy, Harvard Medical School, Boston, Mass.; Consultant in Pathology, Boston Lying-in Hospital, Boston, Mass.; and Free Hospital for Women, Brookline, Mass.; and Hazel Gore, M.B., B.S., Associate in Pathology, Harvard Medical School, Boston, Mass.; Formerly Associate Pathologist, Free Hospital for Women, Brookline, Mass. Paper. Price, \$2.50. Pp. 275, with 279 illustrations. Armed Forces Institute of Pathology, Washington, D. C., 1960. For sale by the American Registry of Pathology, Armed Forces Institute of Pathology, Washington 25, D. C.

Doctors Hertig and Gore are to be complimented on the production of this superb fascicle dealing with Tumors of the Vulva, Vagina and Uterus. In combination with their companion fascicles (already published) on Tumors of the Ovary and Fallopian Tube, and Hydatidiform Mole and Choriocarcinoma, they have provided the medical world with the most concise and authoritative work on gynecologic tumor pathology available.

The authors present their views with clarity and decisiveness, and yet provide the reader with the viewpoints of others through liberal quotation and reference. Not all pathologists will agree with the statement that obtaining multiple biopsies of the cervix is the preferred procedure in the diagnosis of squamous carcinoma *in situ* of the cervix following a positive cytologic examination. Indeed, the authors elsewhere claim both that semi-serial sectioning of the cervix is required to ensure that a tumor does not show invasion, and also that areas of *in situ* carcinoma are frequently found at the edge of invasive lesions. To rule out coincident invasion, they therefore advocate additional biopsies and endocervical curettage after *in situ* carcinoma has been demonstrated histologically. This subjects the patient to a second

operation which can be avoided with a primary cold conization. It seems probable that the authors recognize this fact as they outline in detail the preferred method of examining a conization specimen. Another suggestion of value is that uteri should be opened by two lateral incisions and bi-valved at the fundus to provide not only a better view of the cavity than the standard anterior approach gives, but also to facilitate section taking.

The photographs are of the usual superb quality and the extensive bibliography is from recent literature for the most part. No resident in pathology or gynecology can consider his training complete if he has not read this volume from cover to cover. It should be in the library of every pathologist, gynecologist and radiologist and will provide instructive reading for anyone interested in the field of gynecologic pathology.

A. R. W. CLIMIE, M.D.

HISTOPATHOLOGY OF THE SKIN. Third edition. By Walter F. Lever, M.D., Professor of Dermatology and Chairman of the Department, Tufts University; Lecturer on Dermatology, Harvard University; Director Dermatology Service, Boston City Hospital; Physician-in-Chief, Dermatology Clinic, Boston Dispensary; Physician (Dermatology), Boston Floating Hospital for Children; Member of the Board of Consultation, Massachusetts General Hospital; Consultant in Dermatology, Peter Bent Brigham Hospital and Robert Breck Brigham Hospital, Boston, Mass. Cloth. Price, \$16.50. Pp. 653, with 320 illustrations of which 8 are in color. J. B. Lippincott Company, East Washington Square, Philadelphia 5, Pa., 1961.

Dr. Lever's textbook on the Histopathology of the Skin is well established as a standard reference on that subject. In the preparation of the Third Edition, the volume has been enlarged considerably in part due to the welcome addition of 47 new photomicrographs, the majority of which are of good quality. The chapter on fungal diseases has been re-written,

several new dermatologic entities have been described and sections on various recently recognized tumors have been added. Among the latter are descriptions of eccrine spiradenoma and poroma, keratoacanthoma and warty dyskeratoma. The text reveals the usual mixture of Latin and English terminology common to all dermatologic literature. In most instances this merely appears incongruous but from time to time it proves confusing. As an example, it is noted in the preface that a new entity called "papulosis atrophicans maligna" is described, but this disease is listed in the index and text as "malignant atrophic papulosis." A certain intuitive and deductive ability is therefore necessary to track the disease down.

It was to be hoped that the confusing discussion of basal cell epithelioma found in earlier editions would be eliminated in the third revision, but this is not the case. Although the author recognizes that basal cell epithelioma is frequently locally invasive and that rare reports of distant metastases have appeared, he prefers to include it among hamartomas of primary epithelial germ cell origin and to consider it benign. This inconsistency is of some significance as it might well result in under treatment of the more actively growing lesions.

The use of the term "nevus" for a variety of cutaneous lesions is deplored by the author who would prefer to include all benign epidermal tumors under hamartomas. In spite of this viewpoint he makes widespread use of the term "nevus" for conditions lending themselves at least equally well to descriptive nomenclature such as "hyperplasia" of specific structures. Unfortunately, only lip service is paid to the concept that a nevus must contain neval cells.

The suggestion that tap water be used to prepare 10 per cent formalin is not in accord with best practice. In some locations this may be possible but the pH of tap water varies considerably from place to place and in some areas an annoying deposit of formalin pigment will occur unless buffered neutral formalin is used.

As in all textbooks other deficiencies are to be found on careful reading. Many are minor and none detract from the basic value of the book as a reference for both dermatologists and pathologists. The necessity for three editions in 12 years is proof of this.

A. R. W. CLIMIE, M.D.

BOOKS RECEIVED

- I. INTERNATIONALER KONGRESS FÜR MEDIZINISCHE PHOTOGRAPHIE UND KINEMATOGRAFIE. 1^{er} INTERNATIONAL CONGRESS ON MEDICAL PHOTOGRAPHY AND CINEMATOGRAFY. 1^{er} CONGRÈS INTERNATIONAL DE PHOTOGRAPHIE ET CINÉMATOGRAFIE MÉDICALES. Düsseldorf, September 27-30, 1960. By Dr. Heinz Orbach, DGPh., Wissenschaftlicher Assistent an der Chirurgischen Universitäts-Klinik, Marburg/Lahn, Germany. Cloth. Price, \$22.00. Pp. 362 with 275 illustrations. Georg Thieme Verlag, Herdweg 63, Stuttgart, Germany, 1962. In the U.S.A. and Canada, Intercontinental Medical Book Corporation, New York 16, N. Y., 1962.
- STRAHLENSCHUTZ IN FORSCHUNG UND PRAXIS. Band I. Jahrbuch der Vereinigung Deutscher Strahlenschutzärzte v. By Hans-Joachim Melching, Freiburg; Hans Robert Beck, Karlsruhe; Hans-Adolf Ladner, Hamburg; und Hans Weigand, München. Nineteen contributors. Cloth. Pp. 251 with numerous illustrations. Verlag Rombach, Freiburg im Breisgau, Germany, 1962.
- EXPOSURE TO RADIATION IN AN EMERGENCY. National Committee on Radiation Protection and Measurements. Report No. 29. Paper. Price, \$.50. Pp. 91. Available only from Section of Nuclear Medicine, Department of Pharmacology, The University of Chicago, Chicago 37, Ill., 1962.
- ELEMENTS OF BIOPHYSICS. Second edition. By James E. Randall, B.S.E.E., M.S., Ph.D., Associate Professor of Physiology and Biophysics, Department of Physiology and Pharmacology, University of Missouri Medical Center. Cloth. Price, \$8.75. Pp. 339, with tables and illustrations. Year Book Medical Publishers, 200 East Illinois Street, Chicago, Illinois, 1962.
- TROPICAL RADIOLOGY. By Howard Middlemiss, M.D., F.F.R., D.M.R.D., Director of Radiology, United Bristol Hospitals; Head of Department of Radiodiagnosis, University of Bristol, Bristol, England. Cloth. Price, \$10.00. Pp. 272, with numerous illustrations. Intercontinental Medical Book Corporation, 381 Fourth Avenue, New York 16, New York, 1961.
- LIVING WITH THE ATOM. By Ritchie Calder. Cloth. Price, \$5.95. Pp. 275, with 24 illustrations. The University of Chicago Press, 5750 Ellis Avenue, Chicago 37, Illinois, 1962.
- IONIZING RADIATION; AN OLD HAZARD IN A NEW ERA. By George Tievsky, M.D., Clinical Instructor in Radiology, George Washington University School of Medicine, Washington, D. C. Cloth. Price, \$8.00. Pp. 154, with 63 illustrations. Charles C Thomas, Publisher, 301-327 East Lawrence Avenue, Springfield, Ill., 1962.

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ROENTGEN DIAGNOSIS

HEAD

DI CHIRO, GIOVANNI. Ophthalmic arteriography. *Radiology*, Dec., 1961, 77, 948-957. (From: Section on Neuroradiology, National Institutes of Health, Bethesda 14, Md.)

The ophthalmic artery is the first sizable intracranial branch of the internal carotid, emerging from the medial aspect of the latter vessel at its exit from the cavernous sinus, coursing first laterally forward and then proceeding medially and somewhat upward. Some of its branches, namely, the lacrimal, supraorbital, posterior and anterior ethmoidal, frontal, and nasal arteries form anastomotic connections between the internal and external carotids.

Contrast filling of the ophthalmic artery and its branches is obtained during carotid angiography. Its demonstration depends primarily on its caliber as it is generally better seen when it is enlarged. Various techniques and procedures during angiography have not resulted in consistently better angiographic demonstration. To obtain visualization of the ophthalmic artery in the frontal projection, the orbits must be projected free from the petrous bones. The first part of the main trunk of the ophthalmic artery is always seen in early lateral angiograms, and fills practically simultaneously with filling of the upper loop of the carotid siphon. In pathologic cases, when the artery is enlarged, the entire main trunk up to its division into the terminal branches may be recognized.

Space-occupying lesions involving the apex and roof of the orbit, such as meningiomas and fibrous dysplasia, will displace the main trunk of the ophthalmic artery. Aneurysms of the ophthalmic artery have been demonstrated. "Tumor-stain" has been seen in ocular tumors such as melanoma and retinoblastoma, and some authors have found pathologic vessels in orbital tumors. Enlarged branches from the ophthalmic artery may supply periorbital meningiomas located on the sphenoid ridge, olfactory groove, and anterior frontal parasagittal region or falx. In instances of internal carotid thrombosis, filling of the carotid siphon from the external carotid, through an enlarged ophthalmic artery, is commonly seen.

Many excellent roentgenograms are reproduced illustrating several of these pathologic findings.—Donald N. Dysart, M.D.

NECK AND CHEST

TRAPNELL, DAVID H. The radiological diagnosis of laryngoceles. *Clin. Radiol.*, Jan., 1962, 13, 68-72. (From: Department of Diagnostic Radiology, St. Bartholomew's Hospital, London, England.)

Laryngoceles are rarely seen in X-ray Departments of General Hospitals, and the author found only 5 descriptions of this lesion in the radiologic literature of the last 20 years. The diagnosis is usually a clinical one and is based upon the history and physical signs. Air spaces have been seen in roentgenograms of the neck which have been mistaken for laryngoceles, particularly if they were taken while the patient performed the Valsalva maneuver, during which normal lateral bulges from the pharynx may be noted. Such normal bulges or pouches may vary in size, being commonly smaller in women than in men. The bulge occurs through the weakest part of the lateral pharyngeal wall—a triangular area limited above by the hyoid bone and the middle constrictor muscle, below by the thyroid cartilage and the inferior constrictor, and anteriorly by the posterior border of the thyrohyoid membrane. The position of this normal bulge from the pharynx is practically the same as that reached by an external laryngocele.

Embryologically, the laryngocele develops from a small pouch or sacculle, i.e., a normal projection from the anterior part of the laryngeal ventricle in infants. If the sac pierces the thyrohyoid membrane at the site of the superior laryngeal vessels, an external laryngocele may result, or it may not pierce the thyrohyoid membrane, and so remains within the larynx to form an internal laryngocele. Internal and external laryngoceles may be present, in which case the single sac is dumbbell shaped, with a narrowed part where it passes through the thyrohyoid membrane.

A case is described in which there was respiratory obstruction due to rapid enlargement of a mixed internal and external laryngocele. Roentgenologically a lobulated air-filled cyst was demonstrated. Resection of the cyst, originally contemplated, was not performed, because the cyst suddenly and spontaneously decreased in size, and the patient lost all his symptoms. Roentgenograms made with the pharynx outlined with barium showed that the air sac did not coat with the barium. Laminagraphy during the Valsalva maneuver demonstrated the position of the air space just lateral to the normal lateral bulges of the pharynx. The internal laryngocele was no longer demonstrable.

To diagnose a laryngocele roentgenologically one should demonstrate an air space in the neck that is present with the patient at rest, and that is separate from the normal lateral bulges of the pharynx appearing during the Valsalva maneuver. It should also be demonstrated that the barium swallow is normal and that no pharyngeal diverticula are present.—Samuel G. Henderson, M.D.

ELLIOTT, G. B., BELKIN, A., and DONALD, W. A. J. Cystic bronchial papillomatosis. *Clin. Radiol.*, Jan., 1962, 13, 62-67. (From: Department of Clinical Pathology, Calgary •

General Hospital, and Provincial Cancer Clinic, Calgary, Alberta, Canada.)

The pseudostratified ciliated epithelium of the respiratory tract shows a pronounced tendency to apparent diffuse papillomatosis over long periods. This is seen characteristically in the nose and paranasal sinuses in adults and in the laryngotracheal region in children. Rarely, similar proliferations occur in bronchi and produce coin lesions or cysts, which in adult life closely mimic bronchogenic squamous epitheliomas pathologically and radiologically. Laryngeal papillomata in childhood may be followed in adult life by bronchial papillomatosis, but such relationship is not inevitable. Carcinomatous change is rare in either laryngeal or bronchial papillomata. While laryngeal papillomata may eventually regress spontaneously after causing notable respiratory obstruction in childhood, the incidence of silent cystic bronchial papillomatosis in such cases is unknown.

In a case discussed by the authors sequential roentgenograms covering 7 years showed a slow growth of an ill-defined lesion with a marked tendency to cavitate and to contain a fluid level. The wall of the cavity sometimes appeared thin, and sometimes thick and nodular. The lesion was eventually successfully removed by resection, and after 2 years there has been no roentgenologic evidence of recurrence.

Failure to recognize the entity has led to the false diagnosis of malignant disease microscopically in some recorded cases. The cause is unknown, but there is reason to suspect that the tumor is of viral origin.—*Samuel G. Henderson, M.D.*

FRASER, ROBERT G. Measurements of the calibre of human bronchi in three phases of respiration by cinebronchography. *J. Canad. Assoc. Radiologists*, Dec., 1961, 12, 102-112. (From: Royal Victoria Hospital, Montreal, Canada.)

A method of measuring the caliber of human bronchi is described. The dynamic activity of the tracheo-bronchial tree was recognized as early as 1920, and some of the early investigators considered these movements to be bronchial peristalsis. However, this observation has since been refuted.

During the past two years, 55 bronchographic examinations of 53 patients have been carried out at the Royal Victorial Hospital in Montreal, Canada. Fluoroscopic, roentgenographic and cine-fluorographic techniques were applied to each examination. Of the 55 bronchographies performed, 32 were selected as being technically adequate for bronchial measurement. Pulmonary function studies were performed on 20 of these 32 patients. Ten cases of bronchiectasis were excluded because of severe bronchial deformity. Bronchial measurements were made at maximum inspiration, quiet expiration, and forced expiration.

A significant variation in the caliber of the larger bronchi between the sexes was noted. The larger bronchi were consistently larger in men than in women, by an average of 1.8 mm. in the right lung and 2.8 mm. in the left lung. Age appeared to have no bearing on variations of measurements. It was found that the diameter of each successive bronchial division is roughly proportional to the diameter of its predecessor in the same ratio for all the major bronchi. Percentage reduction in the tracheal caliber from maximum inspiration to forced expiration varied from 33 per cent to 70 per cent with more narrowing in the chronic bronchitis and emphysema groups than in the other groups (average 39 per cent). As in the bronchi, narrowing occurred extremely rapidly, usually in less than 30 milliseconds. Patients with chronic bronchitis or emphysema, or both, almost invariably showed a remarkable collapse of their central bronchi during coughing. In one patient with bronchitis, the caliber reduction of the lower lobe bronchus was from 11 mm. to 1.5 mm. (86 per cent), while the segmental bronchus in the same patient reduced from 8 mm. to 5 mm. (38 per cent). Thus, at the point of maximum narrowing, the segmental bronchus was over three times the caliber of the main lower lobe bronchus. This reversal of the ratio of lower lobe bronchus to segmental bronchus occurred frequently in patients with chronic bronchitis, the large bronchus collapsing down to almost a linear shadow and presenting a striking contrast to the several segmental bronchi of larger caliber distal to it.

A detailed chart of all measurements made in this investigation is included. Other charts, graphs, and reproductions of bronchograms are also included. Techniques of examination and measurement are described.—*Douglas S. Kellogg, M.D.*

SMITH, R. ABBEY. Some controversial aspects of intralobar sequestration of the lung. *Surg., Gynec. & Obst.*, Jan., 1962, 114, 57-68. (From: The Thoracic Surgical Unit, King Edward VII Chest Hospital, Warwick, England.)

Five patients aged 6 months, 3 years, 18 years, 36 years, and 41 years are reported and the author discusses several controversial aspects of the disease. The congenital theory of coincidence of lung cysts and anomalous arteries is deflated. Another hypothesis that intrapulmonary sequestration is the end result of an area of inflammation is opposed.

Details of the surgical findings in the 5 reported cases are supported by pathologic description and photographs. The author considers the presence of an anomalous vessel very significant in diagnosing the condition by use of angiocardiology. This vessel has definite characteristics as to size, length, origin, color, thickness, distribution to certain sections of the lung, etc.

Associated defects in the pulmonary tissue and pleural lining are further elaborated on by the

author. In his discussion of the surgical pathology of the entity, he deals with the findings in the contiguous lung tissue, venous drainage from the segment, etc. This is a good article and presents some new features of the disease.—*David C. Alftine, M.D.*

WHITE, W. F., SAXTON, H. M., and DAWSON, I. M. P. Pneumocystis pneumonia; report of three cases in adults and one in a child with a discussion of the radiological appearances and predisposing factors. *Brit. M. J.*, Nov., 1961, 2, 1327-1331. (From: Departments of Radiotherapy, Radiology, and Pathology, Westminster Hospital and Medical School, London, England.)

Four cases of pneumocystis pneumonia are reported. They are of unusual interest because 3 of the patients were adults and the occurrence in all was associated with debilitating disease and corticosteroid therapy.

The disease, rare in the United States, is not uncommon in Europe among infants, but is seldom reported in the adult. The classification of the causative organism is debated; most investigators place it among *Candida* or *Blastomyces*. The expression of pathogenic behavior would seem largely dependent upon impaired host resistance. Histopathologically, the disease produces an interstitial pneumonia, fibrosis and dilated alveoli filled with the organism. The involved areas may show emphysematous, cystic changes.

The roentgenologic evolution is described in 3 stages which may coexist: (a) in the exudative stage there is a "ground-glass" symmetric, perihilar density. This gradually extends downward and outward but spares the costophrenic angles. There may be an "air bronchogram." The findings correspond to the stage of proteinaceous exudation into the alveoli; (b) in the stage of collapse the infiltrate loses homogeneity as a result of scattered lobular collapse. Intervening small areas of emphysema produce a honeycombed appearance. Later the atelectatic areas become confluent; (c) during the stage of emphysema there is enlargement of the emphysematous zones, particularly in the lower lung field. The process may progress to interstitial, mediastinal and subcutaneous emphysema. If pneumothorax occurs, there may be little collapse of the rigid affected lung. Depending upon the stage, the process mimics other diseases (bronchopneumonia, pulmonary edema, alveolar proteinosis, eosinophilic pneumonia, etc.) and the roentgenologic diagnosis, difficult at best, is dependent upon clinical data and serial films to provide a sense of the dynamics.

The authors introduce a valuable concept concerning the causes of the disease. The organism is not always considered pathogenic, and clinical manifestations seem to be a factor of impaired host

resistance. Infants who contract the pneumonia often have hypogammaglobulinemia. Of the 4 cases cited, all were suffering from a debilitating disease (Hodgkin's disease, lymphosarcoma, Letter-Siwe disease) which was treated aggressively. Besides antibiotics, all 4 received prednisone. Three adults had radiation therapy to the chest and nitrogen mustard intravenously. It is suggested that these agents predispose the patient to the disease by changing the pulmonary milieu. This may be effected by altering the bacterial flora (antibiotics), directly stimulating the growth of the pneumocystis organism (corticosteroid) or by damaging the structure of the lungs (cytotoxic drugs, radiation).—*Jack Reynolds, M.D.*

HODSON, C. J., and FRANCE, N. E. Pulmonary changes in cystic fibrosis of the pancreas: a radio-pathological study. *Clin. Radiol.*, Jan., 1962, 13, 54-61. (From: The Queen Elizabeth Hospital for Children, Hackney Road, London, England.)

The roentgenologic observations in this study are based on serial roentgenograms from an unselected group of 48 patients. Two features of the disease process affecting the lungs are stressed to give a proper understanding of the roentgen findings: (1) the peculiar tenacious state of the bronchial mucus, which is partly responsible for its obstructive effect; (2) the predominating organism, the *Staphylococcus pyogenes*, which is almost always present in the early episodes of lower respiratory infection in cystic fibrosis of the pancreas.

Acute obstructive bronchitis with emphysema in infants with cystic fibrosis of the pancreas may be rapid in onset and lethal. The roentgenogram shows the lungs or individual segments overaerated, bulging out the chest wall, depressing the diaphragm, and diminishing the heart outline, with multiple small areas of segmental collapse. At autopsy, mucus plugs are found in the bronchi, along with simple alveolar distention.

In more chronic cases there is a linear pattern superimposed on the normal pulmonary vascular markings, consisting of two thin lines running in close association with the shadow of a pulmonary artery, tapering toward the lung periphery. Such lines representing *thickened bronchial walls* can be followed well out into the lung fields in these patients. Pathologically the bronchial wall is found infiltrated by lymphocytes and plasma cells.

In about one-third of the cases the authors found a *small discrete opacity* or group of opacities, located in the middle or outer lung zones, resembling a tuberculous focus of 5 mm. diameter found in adults. It is usually seen in children of around 3 to 5 years. These shadows may disappear and never return, they may recur in exactly the same position, or they may be replaced by thin-walled cyst-like spaces.

Pathologically these are found to be small abscesses or bronchial cavities filled with muco-pus.

Gross varicose *bronchiectasis* may occur in two quite different forms: (1) segmental bronchiectasis affecting a major pulmonary segment; and (2) a variety of bronchiectasis peculiar to staphylococcal disease, described as multiple, scattered "blob" bronchiectasis. The involved areas are small and scattered among the smaller bronchi, or are found in close proximity to the walls of medium-sized bronchi. Suppurative foci in relation to the medium-sized bronchi are found at necropsy. Such abscesses, when their contents are discharged by eroding into a bronchus, probably give rise to localized cystic lesions, forming the basis of the "blob" bronchiectasis.

Other roentgenologic findings are *enlarged hilar lymph nodes* as with any severe respiratory infection, *persistent segmental collapse*, commonly affecting the right middle lobe or the lingular process of the left upper lobe, and *irregular thin-walled "cysts,"* developing as a break-down of areas of acute pneumonic consolidation. As the consolidation resolves an irregular thin-walled cyst or cavity remains.

The pathologic processes of this disease are now understood better, providing a rational basis for therapy, and this may have contributed toward the increasing efficacy of treatment noted during the course of this study.—*Samuel G. Henderson, M.D.*

CANDARDJIS, G., LIVIO, J.-J., and ESSINGER, A. Remarques sur les diverses techniques de coronographie. (Remarks on the various techniques of coronography.) *Radiol. Clin.*, 1961, 30, 323-333. (Address: Prof. Dr. Candardjis, Institut universitaire de radiologie, Hôpital Cantonal, Lausanne, Switzerland.)

The authors discuss the various methods used for coronary visualization, including angiocardiology, cardiac ventriculography, thoracic aortography and occlusion aortography. The latter offers the best visualization of the coronary vessels. Urografin was chosen because its viscosity matches that of a glucose solution of comparable concentration. Further investigation is necessary to produce a satisfactory elective cardiac arrest, since present methods are not completely adequate. Acetylcholine-induced cardiac arrest is thus far the method of choice, but the authors are considering the possibility of producing bradycardia of the central type.

The roentgenographic apparatus includes two systems of electronic relays introduced by Urschel and Roth. One system permits the injection of the contrast material to coincide with the R-wave of the electrocardiogram and the second system controls the timing of the roentgenographic exposures during a selected phase in the electrocardiogram. Cine-roentgenography is preferred despite the fact that the definition is not as clear as in standard roent-

genography. However, 30 lines/cm. compares fairly well with the 70 lines/cm. of the latter.—*J. Zausner, M.D.*

SCADDING, J. G. Prognosis of intrathoracic sarcoidosis in England: review of 136 cases after five years' observation. *Brit. M. J.*, Nov., 1961, 2, 1165-1172. (Address: Director of Studies, Institute of Diseases of the Chest, Brompton, England.)

The author reports on 136 cases of intrathoracic sarcoidosis before 1955, with emphasis on the condition of the lungs after 5 years' observation. The patients were divided into 4 groups according to the type of roentgenographic abnormality: Group 1—enlarged hilar lymph nodes only; Group 2—enlarged hilar lymph nodes and lung shadows; Group 3—lung shadows without evidence of present or past hilar lymph node enlargement; and Group 4—fibrosis judged to be already present.

The condition of the lungs after five years' observation is recorded as follows:

Group	Total cases	Normal roentgenogram	Abnormal roentgenogram		
		No symptoms	No symptoms	Mild symptoms	Severe symptoms
1	32	27	4	1	0
2	40	23	2	11	3
3	37	16	6	8	6
4	27	0	0	9	11

The good prognosis of the disease in Group 1 is borne out: 84 per cent showed a clear roentgenogram and 97 per cent had no symptoms after 5 years. During the 5 year period, 10 of the 32 cases developed lung mottling in from 1 to 10 months after the detection of enlarged hilar lymph nodes, but 8 of these completely cleared.

The usual picture of the abnormal roentgenograms after 5 years in Groups 1, 2, and 3 was residual fibrosis, although several patients had only persistent hilar lymphadenopathy.

In Group 4, 6 patients died of pulmonary fibrosis due to sarcoidosis, within 6 to 25 years after the onset of the disease. Of the 20 patients who lived, 7 were improved, 3 were worse after 5 years, while 10 remained unchanged. Three patients in the series died of unrelated causes. The author points out that his series is not representative, since many of the Group 4 patients were referred to him because they were not doing well.

No patient who attained a normal roentgenogram showed evidence of recurrent disease.

The association between erythema nodosum, bilateral enlargement of the hilar lymph nodes, and a good prognosis was noted in this series confirming the reports by Lofgren and others. Of the 66 patients who developed a clear roentgenogram within 5 years, erythema nodosum was noted at the onset in 17 cases (26 per cent), while it was only seen in 1 of 70 with persistent abnormal roentgenograms.

On the other hand, sarcoid skin lesions were significantly associated with a poor prognosis for the lung changes.

Sarcoidosis of the eye, generalized lymphadenopathy, and moderate splenic enlargement did not seem to affect the prognosis of the lung changes. Pregnancy appeared to cause temporary suppression of reversible elements in sarcoid lung changes, with recrudescence after delivery, and otherwise had no effect on the course.

On the basis of his figures, the author estimated 6 to 7 per cent mortality within 10 to 15 years of those patients with sarcoid infiltration of the lungs in a prefibrotic (mottling) stage. The less favorable course in North American Negroes accounts for the higher mortality figures in other reports.

A minority of patients was treated with steroids and the author expresses a firm opinion on the "suppressive" nature of the responses with no effect on the eventual attainment of a clear roentgenogram. Of 9 patients with established pulmonary fibrosis, 4 experienced enough symptomatic relief to justify long-term maintenance doses.—*John R. Dehner, M.D.*

SMITH, R. ABBEY, WHITEHEAD, T. P., MORRIS, LORNA, and WILLIAMS, H. PARRY. Functionally active intrathoracic neuroblastoma. *Arch. Dis. Childhood*, Feb., 1961, 36, 82-89. (From: The Thoracic Surgical Unit, King Edward VII Memorial Chest Hospital, Warwick, and Paediatric Department, Coventry and Warwickshire Hospital, Warwick, England.)

It is now apparent that certain neuroblastomas may be associated with the secretion of pressor amines. This paper adds another case, in detail, to the list of such tumors in children. The microscopic pathology is illustrated and the assay of the catecholamines in both the urine and the tumor is recorded as being elevated.

The principal clinical signs are sweating and pallor in an apparently otherwise well child. Lethargy is noted and, under observation, intermittent fever and hypertension are found.

The potential complexity of the cell content of any tumor originating from the primitive neural crest must make classification difficult. However, it is easy to understand how more than one element

can be represented and ganglioneuroblastoma would, perhaps, be a more accurate designation of the tumor described. The authors postulate that this type of tumor may undergo spontaneous reversion to a non-functioning ganglioneuroma of adult life.

There does not seem to be any increased risk of operation on these children in spite of the increase in the pressor amines. The Hingerty test is suggested as being most useful in the screening of these infants, but the urinary determination of vanilmandelic acid (V.M.A.) represents a more reliable method for ascertaining the presence of an adrenaline-secreting tumor.

There are 2 roentgenographic and 4 photomicrographic reproductions.—*John L. Gwinn, M.D.*

BLOOR, COLIN M., and LOWMAN, ROBERT M. The transfemoral approach to coronary arteriography, with particular attention to right coronary artery visualization: an experimental study. *Radiology*, Dec., 1961, 77, 990-994. (From: The Departments of Pathology and Radiology of the Yale University School of Medicine, New Haven, Conn.)

Lack of constant filling of the right coronary artery has been one of the persistent problems of coronary arteriography. Preferably, the catheter tip should be positioned near the anterior aortic sinus of Valsalva to opacify the right coronary artery. This problem has become particularly important to the authors' group, during an investigation of allylamine-injured dogs, since a previous report indicated that the induced coronary lesions were most frequent in the right coronary artery.

To further study this aspect of coronary arteriography both the transcarotid and transfemoral catheter techniques were performed on unselected normal mongrel dogs and the results compared. Various filming procedures were used in each technique and injections were made both in asystole as well as during regular cardiac rhythm.

A comparison of the two techniques reveals that in each transcarotid approach the catheter was positioned in the left posterior sinus of Valsalva. Injection from this location produced excellent left coronary visualization. The right coronary artery was likewise visualized in all cases but not as well in some instances as on the left. Using the transfemoral approach, the tip of the catheter was located in the anterior sinus of Valsalva and arteriography produced excellent visualization of both the right and left coronary arteries. The current study would indicate that the transfemoral approach is preferable.—*Edward B. Best, M.D.*

MOERSCH, HERMAN J. Benign esophageal dysfunction and disease. *Am. J. Digest. Dis.*, Oct., 1961, 6, 964-977. (From: Section of

Medicine, Mayo Clinic and Mayo Foundation, Rochester, Minn.)

The esophagus is a dynamic organ possessing an intricate mechanism and it is prone to all the disturbances of function and diseases that may involve the remainder of the gastrointestinal tract. These are discussed under the headings of hiatal hernia, achalasia, diffuse spasm, diverticulum, and esophagitis.

It is estimated that more than ten million people in the United States are afflicted with hiatal hernia of which perhaps 25 per cent produce symptoms. Three major types are recognized: sliding (82 per cent), paraesophageal (8 per cent), and short esophagus (10 per cent). The larger hernias are more apt to be symptomatic. The condition most often affects older obese individuals and may be confused with cholecystitis, peptic ulcer, and coronary heart disease. Motility pressure studies and esophagoscopies are valuable adjuncts to roentgenography. Indications for surgery are severe bleeding, ulceration, and obstruction.

Achalasia is an easy roentgenographic diagnosis, but it can be confused with a large intraluminal benign tumor or a scirrhous carcinoma of the cardia. In the early cases, motility studies are valuable, aided by the mecholyl test. Treatment with dilatation is 70 per cent satisfactory, but there is a 1 per cent risk of perforation. A Heller muscle splitting operation offers 85 per cent chance for relief.

Diffuse esophageal spasm characterized by simultaneous irregular contractions produces pain and dysphagia. During remission of symptoms the roentgen examination is negative. The condition is of functional origin, being most frequently found in the dynamic type of person.

Esophageal diverticula may be of the traction or pulsion type. The former are seldom symptomatic, but the latter usually are associated with symptoms of dysphagia, regurgitation, and belching of gas. However, these symptoms invariably will be due to other associated disorders such as diffuse spasm, achalasia, or hiatal hernia. It is therefore mandatory that such associated disorders be eradicated at the time of diverticulectomy.

Esophagitis can be asymptomatic and its greatest hazard is hemorrhage. The etiology may have an allergic or obstructive basis, or it may be due to regurgitation of gastric secretion. Long term conservative treatment is advised.—*Arch H. Hall, M.D.*

ABDOMEN

GRIGG, E. R. N. (Chicago, Ill.) Esophago-gastrointestinal leiomyo(sarco)mas. *Am. J. Med.*, Oct., 1961, 31, 591-618.

The author finds that smooth muscle tumors occur all along the alimentary canal. The order of regular relative frequency, by organs, is stomach, esophagus,

small intestine (jejunum, duodenum and ileum), colon, rectum, mouth and pharynx. The first comprehensive review of these tumors was compiled by Virchow in 1863. After Virchow about 2,000 esophagogastrintestinal leiomyo(sarco)mas have been reported in the universal literature.

Palpable, nodular, but asymptomatic smooth muscle tumors occur quite frequently within the wall of the alimentary canal (interstitial type). The comparatively few which increase in size (intramural, intraparietal), grow either towards the outside (subserous) or towards the inside (submucous). Peristalsis may extrude them (extraluminal) or intrude them (intraluminal), whereupon they acquire a polypoid appearance, sessile or pedunculated. These tumors are usually solid, well demarcated (never encapsulated), occasionally multiple. They may ulcerate, bleed and/or calcify. The benign form (leiomyoma) is more frequent (in most tabulations, by ratio of 3:1) than the malignant form (leiomyosarcoma).

A positive diagnosis of tumor type can be made only through histologic examination. The symptomatology and roentgenologic findings of "digestive" leiomyo(sarco)mas vary with the type, size and location of the tumor; hence, no true generalization can be attempted. Eventually, extraluminal types cause pressure symptoms, the intraluminal types occlude, a few submucous and subserous types obstruct (by intussusception or volvulus). The most frequent symptom is bleeding from the gastrointestinal tract, with ensuing anemia. The most common roentgenologic features are benign appearance (even in leiomyosarcomas), ulceration, calcification, and an over-all involvement more extensive than clinically expected.

The author gives a very complete discussion of these types of lesions and includes a very extensive bibliography.—*Peter C. Truog, M.D.*

BACHRACH, WILLIAM H. Observations upon the complete roentgenographic healing of neoplastic ulcerations of the stomach. *Surg., Gynec. & Obst.*, Jan., 1962, 114, 69-82. (From: The University of Southern California School of Medicine and The Veterans Administration Hospital, Los Angeles, Calif.)

This article presents the results of an 11 year search for indisputable evidence of healing of proven gastric malignancies under medical ulcer management. The rewards are largely disappointing. The need for improving roentgenologic examinations is noteworthy.

Gastric cancer can develop in anyone, including persons with present or past gastric ulcer. The requirements for a properly documented case of healed neoplastic ulcer are: (1) that pretreatment and post-treatment roentgenograms be technically satisfactory and show similar areas in detail, (2) that the

lesion found at surgery be at the same site as the treated lesion, and (3) that the presence of cancer be demonstrated sufficiently soon after the alleged healing to permit conclusion that the lesion was, in fact, cancer from the outset.

In the interpretation of the therapeutic test, the requirements are: (1) that the lesion reduce in size, and (2) that within a further reasonable period the lesion disappear completely. The value of the therapeutic trial in the differential diagnosis of gastric ulcer rests on the premise that a malignant ulcer will not show healing on medical management. The author confirms this premise by a search of the world literature and a survey of the experiences in a 10 year period of 76 radiologists which yielded only 10 cases of complete roentgenologic disappearance of neoplastic gastric ulcer. He states that it is doubtful if complete roentgenologic healing of cancerous ulcer has ever been reported.—*David C. Alftine, M.D.*

MARSHAK, R. H. Roentgen findings in lesions of the small bowel. *Am. J. Digest. Dis.*, Nov., 1961, 6, 1084-1114. (From: The Department of Radiology, Mount Sinai Hospital, New York, N. Y.)

For this study 8 ounces by volume of barium sulfate and water to make 16 ounces are employed by using commercial USP barium sulphate with a suspending agent. Compression roentgenograms of the terminal ileum are necessary. Barium enema examination is advisable to exclude obstruction in the colon, before the small bowel study is undertaken.

The findings of dilatation of the bowel lumen, segmentation of the barium column, hypersecretion, motility changes and alterations in the mucosal markings are more specific than suspected and sufficiently important to be of diagnostic value in the malabsorption syndrome. (1) *Idiopathic steatorrhea (sprue)* is characterized by dilatation, best seen in the mid and distal jejunum. Segmentation, which is most marked in the ileum, appears in two forms, immediate and delayed. Worm or string like strands of barium are seen between the segmented clumps of barium. The residual barium may appear as coarse, mottled or amorphous. Hypersecretion is common. Thickening of the folds occurs. The "moulage sign" refers to the appearance of the small intestine in sprue, which resembles a tube into which "wax has been poured and allowed to harden," occasioned by apparent effacement of the mucosal folds. (2) *Secondary sprue*. In lymphosarcoma most cases do not produce the sprue pattern. In 42 patients with lymphosarcoma, 4 had a sprue pattern and 2 had a sprue pattern with thickening of bowel wall suggestive of tumor infiltration. Whipple's disease had roentgen findings of sprue pattern with less dilatation and more thickening of the folds.

There were 4 cases, 3 with above described findings and 1 with normal small bowel. (3) *Pancreatogenous steatorrhea*. The findings were usually normal.

Regional enteritis is divided into stenotic and non-stenotic type. The valvulae conniventes are blunt, flattened and thickened. The bowel lumen becomes irregular within; later the mucosa assumes a cobblestone appearance as a result of ulceration. When the lumen is narrowed by cicatricial contraction, skip areas represent a characteristic feature. Pseudodiverticula show eccentric skip areas. Loops may appear to surround a mass which is often not abscess but indurated mesentery. In the stenotic stage, dilatation of the proximal intestine may be marked. The terminal ileum is most frequently involved, and the string sign is most noted in this region. Despite this narrowing, complete intestinal obstruction is rare. This string sign does not always indicate fibrosis and stenosis. Ulceration, fistula and perforation are most frequent in the distal ileum; less common in the jejunum and duodenum; involvement of the colon is not infrequent. Recurrence at the site of the new terminal ileum is common in patients who have had a sidetracking operation. Carcinoma was seen in the small bowel in 2 patients with long standing enteritis.

The lymphosarcoma of the small intestine produces a paucity of symptoms and signs which makes the diagnosis difficult until late. The predominant invasion of the mesentery by lymphosarcoma infrequently causes obstruction in contrast to the metastatic carcinoma with mesenteric involvement in which incomplete obstruction is common. The polypoid form may be a lead point to intussusception. The intramural invasion may cause a narrowed area and relative dilatation, the so-called "aneurysmal" dilatation. Multiple small pea-sized nodular defects are usually observed in the ileum and may be seen in the colon. An endo-exo-enteric form with excavation is also noted, as seen with other sarcomas of the intestine.

In Hodgkin's disease the same patterns occur as in lymphosarcoma, except aneurysmal dilatation, fistula and perforation. Fibrosis and tapered narrowing are not infrequently noted.

Carcinoma arises predominantly from the jejunum and exhibits the same appearance as elsewhere in the intestine. Carcinoid is found mostly in the distal ileum and may be difficult to differentiate from carcinoma or other nodular intraluminal filling defect.

Lupus erythematosus and periarteritis cause minimal inflammatory changes.

Segmental infarction may be secondary to obstruction or may occur as a primary manifestation. In both instances, it represents an emergency and usually results in gangrene or perforation, but at times the bowel recovers and becomes stenotic with obstruction.

Other lesions to be considered in the differential diagnosis include: Metastatic carcinoma, especially

near the ligament of Treitz; hemangioma which usually contains multiple phleboliths and produces submucosal defects without obstruction; polyps which, particularly if small, are detected with difficulty—the larger ones are symptomatic and seen to lead to intussusception; protein-losing gastroenteropathies, as described by Menetrier; and scleroderma in which the findings are similar to those seen in the esophagus, the dilatation being striking and most marked in the region of the duodenal loop.

The article is profusely illustrated with 34 roentgenographic reproductions of various lesions.—*H. Joseph Cronin, M.D.*

SAMPSON, P. A., and WALKER, F. C. Dilatation of the colon in ulcerative colitis. *Brit. M. J.*, Oct. 1961, No. 5260, 1119–1123. (From: Department of Surgery, University of Birmingham, Birmingham, England.)

This article deals with one of the uncommon and serious complications of ulcerative colitis.

The so-called toxic dilatation is a prelude to perforation of the colon and surgical intervention is indicated as soon as anemia and electrolyte imbalance (if present) are corrected. During the 5 years preceding the article, 168 cases of ulcerative colitis came to surgery, and of these 14 had dilatation of the colon. All 14 had total colectomies, which the authors believe to be the surgical method of choice, with a low mortality rate of 30 per cent.

It is suggested that neither hypokalemia nor destruction of the myenteric plexus is an important etiologic factor in the development of this condition. A more likely explanation would appear to be that it is due to structural damage to smooth muscle by ulceration and inflammation advancing through the thickness of the intestinal wall.

The value of simple roentgenographic examination of the abdomen without recourse to barium studies, which would be dangerous in such circumstances, is emphasized.

Four illustrative cases are presented.—*R. L. Turner, M.D.*

KAISER, E. Congenital and acquired changes in gallbladder form. *Am. J. Digest. Dis.*, Oct., 1961, 6, 938–953. (From: Department of Surgery, Stadtsptal Waid, Zürich, Switzerland.)

Apart from the gallbladder diseases caused by inflammation and stone formation, there are also less frequently occurring congenital and acquired changes in the form of the gallbladder, the clinical importance of which is controversial. The congenital changes of form are: the pendulous gallbladder, syphonopathy, or the acutely flexed gallbladder, Phrygian cap, hour-glass form, diverticula, septa, and dilated Luschka ducts. The acquired changes are:

the adenomyofibromatosis of the collum-cysticus segment, the controversial sclerosis of the collum-cysticus sphincter, and the frequent strawberry gallbladder.

The main thesis of this paper is that the changed form of these gallbladders does not necessarily explain their pathologic significance. When stasis is the result of the altered form of the gallbladder, it may in turn lead to stone formation and inflammation which then cause the first discomfort of the patient. All of the conditions listed above can conceivably lead to dyskinesia (stasis) and inflammation. Conditions such as cholesterosis can be termed a true prelithiasis and can cause symptoms identical to those of patients suffering from lithiasis.—*Arch H. Hall, M.D.*

BERK, J. EDWARD. Postcholecystectomy syndrome. *Am. J. Digest. Dis.*, Oct., 1961, 6, 1002–1016. (From: Departments of Medicine, Sinai Hospital of Detroit and Wayne State University College of Medicine, Detroit, Mich.)

The postcholecystectomy syndrome is a loosely-used, nonspecific clinical term that broadly refers to a variety of symptoms of different causes. At times the true cause may not even be evident at surgical exploration.

The syndrome can stem from an erroneous initial diagnosis of biliary disease prior to the cholecystectomy. Gaseous dyspepsia is not specifically related to gallbladder disease. It is more commonly associated with inadequate dentition, air swallowing, hiatal hernia, colonic dysfunction, overuse of laxatives, peptic ulcer, coronary disease, tension or anxiety states, or even cancer in other organs. A thorough preoperative survey of the above listed possibilities prior to every cholecystectomy is indicated.

Incomplete surgery resulting in a cystic duct remnant, overlooked ductal stone, overlooked malignancy, or biliary fistula may be a causative factor. Injury during surgery producing bile peritonitis or bile duct stricture should be considered. Residual inflammatory changes in adjacent structures such as cholangitis, hepatitis and pancreatitis may produce symptoms. Stenosis of the sphincter of Oddi is an occasional cause of distress and can be detected by intravenous cholangiography. Pyloro-duodenal adhesions may be distressing after gallbladder removal.

The term biliary dyskinesia is considered by some to be a major factor for unsatisfactory results after cholecystectomy. By using serial cholecystography, transparieto-hepatic vesicular puncture with radio-manometry, chronovolumetric estimation of bile flow using biliary drainage, and preoperative radio-manometry it may be shown that functional derangements commonly coexist with organic disease.—*Arch H. Hall, M.D.*

GYNECOLOGY AND OBSTETRICS

HUGHES, ROBERT R., and CURTIS, DEAN D. Uterine phlebography: correlation of clinical diagnoses with dye retention. *Am. J. Obst. & Gynec.*, Jan., 1962, 83, 156-164. (From: The Department of Obstetrics and Gynecology, Baylor University College of Medicine, and Jefferson Davis Hospital.)

Uterine phlebograms are roentgenograms of the venous outflow of the uterus, obtained by injecting radiopaque media into the myometrium of the fundus. By taking immediate and delayed roentgenograms, the rapidity of the blood outflow, the number and size of the blood vessels, and the location of the venous drainage of the uterus and adnexa can be demonstrated.

The technique of injection is similar to that outlined by Topolanski-Sierra. Preparation similar to that done for hysterosalpingography is performed with the patient in the lithotomy position. No premedication is given. A special cannula with a needle is inserted through the endocervical canal to the fundus. The needle is then cleared of air and projected through the cannula into the myometrium. One hundred and fifty units of hyaluronidase in 3 ml. of normal saline is injected into the myometrium. Twenty milliliters of renografin, 60 per cent, is then injected following an intravenous sensitivity test. The dye is injected in a period of 30 to 40 seconds. A film is exposed immediately at the end of the injection and a second film 20 seconds later. If intravenous pyelography is desired, the usual number and intervals for those films are obtained.

The purpose of this study is to correlate the venous drainage of the uterus and adnexa with a clinical diagnosis. One hundred and five patients were included in this study, 11 of whom were considered gynecologically normal with normal phlebograms. These were compared with 94 patients with various pelvic conditions including 22 with findings compatible with the pelvic congestion syndrome.

The uterine phlebograms demonstrate definite physical changes in the venous drainage of the uterus and adnexa in patients with various clinical diagnoses. This paper outlines these findings.—*Eugene J. McDonald, M.D.*

DOCKERTY, MALCOLM B. Malignancy complicating endometriosis: pathologic features in 9 cases. *Am. J. Obst. & Gynec.*, Jan., 1962, 83, 175-179. (From: The Section of Surgical Pathology, Mayo Clinic and Mayo Foundation, Rochester, Minn.)

Nine cases are presented in which carcinoma apparently originated from lesions of both internal and external endometriosis. The author believes that such a complication occurs much more frequently than is indicated by this type of sampling, in which actual proof of the sequence is unquestioned.

Although endometriosis can often be diagnosed from pelvic examination, in patients over 40 years of age it is unwise to regard an adnexal mass as representing benign endometriosis until this is proved by surgical exploration.—*Eugene J. McDonald, M.D.*

GENITOURINARY SYSTEM

ALLEN, R. PARKER, and CONDON, VIRGIL R. Transitory extraperitoneal hernia of the bladder in infants (bladder ears). *Radiology*, Dec., 1961, 77, 979-983. (From: Radiology Department, Children's Hospital, Denver, Colo.)

There are three types of herniation of the bladder: extraperitoneal, in which the bladder protrudes through the inguinal ring, remaining entirely outside the peritoneum; paraperitoneal, which is also an extraperitoneal protrusion with an adjacent peritoneal hernia; and intraperitoneal, in which a more superior portion of the bladder carries its peritoneal covering into the inguinal ring. Transitory lateral protrusions of the urinary bladder which have been shown to be extraperitoneal herniation through the internal inguinal ring into the inguinal canal ("bladder ears") have been demonstrated in 9 per cent of intravenous pyelographic studies of infants under the age of one year. Of the 35 infants showing this condition, 27 were males and 33 were less than 6 months of age. These protrusions were most often seen when the bladder was partially filled and were transitory.

Their occurrence is probably related to the size and position of the bladder in infants and to the persistence of a large inguinal ring. This probably represents a variation in normal development even though the instance of clinical inguinal hernia is higher than is expected in the normal population.

Illustrative roentgenographic reproductions are presented.—*Walter H. Jarvis, Jr., M.D.*

HALE, BURT B., and GRAINGER, FRANK A. Percutaneous transfemoral aortography in the investigation of hypertension of renal origin. *J. Canad. Assoc. Radiologists*, Dec., 1961, 12, 126-132. (From: Department of Radiology, Royal Victoria Hospital, Montreal, Canada.)

The demonstration by Goldblatt of the potential part played by narrowing of the renal artery in the etiology of hypertension opened up a vast new field in the investigation and treatment of this disease. Within the past decade many workers have investigated the problem with the use of contrast visualization of the renal arteries. In most of these investigations, visualization of the renal arterial system has been via the translumbar route. The authors state that in the experience at their institution translumbar aortography has not yielded consistently satisfactory visualization of the renal arteries.

- Because of this, and the potential hazards of this approach, they have adopted the method of catheterization of the femoral artery.

In their series of 72 renal angiograms, 53 were of patients with hypertension of suspected renal origin. Of the 72 angiographic procedures, 9 were failures. The reasons for the failures are described. Of the 63 successful examinations, equal and adequate visualization was obtained in 48. In 46 hypertensive patients, arteriographic abnormalities were found in 26 (56 per cent). Of 13 constricting lesions demonstrated, 5 showed post-stenotic dilatation. Eleven of the 13 narrowings were interpreted as being due to atherosclerotic plaques, one to an adhesive band, and the other uncertain. One case of particular interest, with a definite stenosis and marked post-stenotic aneurysmal dilatation of the main renal artery, showed multiple tiny interlobar artery aneurysms suggesting periarteritis nodosa. This was the clinical diagnosis, and was pathologically proven.

There were 20 hypertensive patients with normal angiograms, and 16 of these revealed a normal pyelogram. Of interest is the fact that 12 hypertensive patients with abnormal angiograms revealed no pyelographic abnormality. Even this small number of cases is quite suggestive that normal pyelographic studies in no way exclude the presence of renal artery abnormality. It is noted that 3 patients with localized stenotic vascular lesions were normotensive.

The technique of the procedure and the indications, contraindications and complications are discussed. Several excellent reproductions of aortograms are included.—*Douglas S. Kellogg, M.D.*

VIAMONTE, MANUEL, JR., MYERS, MILTON B., SOTO, MANUEL, KENYON, NORMAN M., and PARKS, RAYMOND E. Lymphography: its role in detection and therapeutic evaluation of carcinoma and neoplastic conditions of the genitourinary tract. *J. Urol.*, Jan., 1962, 87, 85-90. (From: The Departments of Radiology, Urology and Surgery, University of Miami School of Medicine, and Jackson Memorial Hospital, Miami, Fla.)

Although the first roentgenographic demonstrations of the lymphatic system in the living human being were made in the early 1930's, this method of roentgen diagnosis has received little attention in the American literature until recently.

The lymph vessels are minute transparent superficially located structures which can be identified by the injection of a suitable colored water soluble medium such as patent blue violet. This dye mixed with xylocaine is injected subcutaneously at multiple sites and within one hour after injection the lymphatic vessels can be identified. When the lower extremities are used, it is important to mobilize both feet with Thomas splints. A one and one-half inch transverse or longitudinal incision is made just prox-

imal to the site of injection of the blue dye. The lymphatic vessel is identified and an untied ligature placed around it. A No. 27 or 30 needle is then inserted, to which is attached a small polyethylene tube used to catheterize the lymphatic vessel. When this is satisfactorily accomplished, approximately 12 cc. of ethiodol is injected at a rate of approximately 0.2 cc. per minute. Too rapid injection results in extravasation, pain, and intravenous transport of the oily medium. After injecting the first 2 cc. of ethiodol, roentgenograms are made of the ankle and of the pelvis in order to determine if there is any extravasation, and also to identify the positive signs of lymphatic rather than venous channels. The wound is closed following which anteroposterior roentgenograms are taken of the legs, thighs, pelvis, abdomen, and thoracic area. Anteroposterior roentgenograms of the pelvis and abdomen made 24 to 48 hours after injection help to evaluate the visualized lymph nodes. These may remain visible for 2-3 months and can be studied by serial roentgenograms.

The lymphatic channels can be recognized on the roentgenogram by their dichotomic divisions and by notches which appear every 0.5 to 1 cm. representing the lymph valves. The first stage lymph nodes in the lower extremities are the superficial inguinals. From here, the medium opacifies the deep inguinal lymph nodes, the iliac nodes, and the para-aortic chain. The latter drain into the cisterna chyli at about the level of the second lumbar vertebra. The opaque medium reaches the thoracic duct and the supraclavicular fossa in about one hour after the beginning of the injection into the foot.

The normal lymph nodes, as visualized by this method, are variable in size and shape. Marginal indentation is noted at the site of the lymph node hilus which corresponds to the efferent lymphatics. These are usually larger than the afferent lymphatics in the normal individual.

In addition to injecting the lower extremities, the authors have also used the dorsal lymphatics of the penis from which there is rapid transfer of the ethiodol into the inguinal lymph nodes.

By these methods, detection of lymph node metastasis from genital organs and urinary tract has been possible when otherwise unsuspected on a clinical basis. Lymphography aids in showing the relation of abnormal pelvic and abdominal masses when there may or may not be some displacement of the ureters. Patients with postadenectomy edema may be studied by this method. If the edema is due to blockage of the lymphatics, one may expect to see dilated lymphatic channels and such findings as dermal backflow are not uncommon. In other instances, residual lymph nodes may be detected following surgery for the removal of metastatic carcinoma in this distribution. Acute and chronic inflammatory lymph nodes show a different pattern than those which are invaded by neoplasm.

The serious complication of this procedure could

be secondary pulmonary fat embolism from intravenous injection of the contrast medium. However, if the procedure is carried out properly and the injection is extremely slow, there should be little or no chance of this complication.—*George W. Chamberlin, M.D.*

SCHAFER, BURTON, GOULD, R. JOHN, WALLACE, SIDNEY, JACKSON, LAIRD, IVKER, MILTON, LEBERMAN, PAUL R., and FETTER, THEODORE R. Urologic applications of lymphangiography. *J. Urol.*, Jan., 1962, 87, 19-96. (From: The Departments of Radiology and Urology, a Division of the Philadelphia General Hospital and the Departments of Radiology, Medicine and Urology of the Jefferson Medical College, Philadelphia, Pa.)

The authors report on the clinical applications of lymphangiography in the study and evaluation of 180 patients, 46 of whom had lesions involving the genitourinary tract. Their technique has previously been described and briefly consists of localization of the lymphatic vessels with blue dye, cannulation, and slow injection of an oily contrast substance with subsequent visualization of the inguinal, pelvic, retroperitoneal lymph nodes, thoracic duct, and supraclavicular lymph nodes. In many instances, this procedure is combined with intravenous and retrograde pyelography and cavography.

The presence of metastatic malignancy without palpable lymph nodes may be detected as illustrated in patients with carcinoma of the penis, prostatic carcinoma, testicular malignancies, carcinoma of the bladder and kidney. This procedure may be used in the surgical management of the patient as an aid in determining the type and extent of treatment. The presence of collateral channels connecting the right and left lymphatic chains and retroperitoneal and pelvic regions indicates the need for bilateral lymph node dissection for the control of spreading malignancies. The completeness or incompleteness of the surgical removal of the lymph nodes and lymphatics can be demonstrated by this method. The radiation effects on lymph node metastases can also be evaluated by the use of lymphangiography.

Complications from the procedure have been few and mild. In one patient with extensive metastatic malignancy and complete block of retroperitoneal lymphatics the injection of a large amount of contrast substance resulted in pulmonary infarction presumably as the result of communication between the lymphatic and venous systems in the retroperitoneal area. This complication can be avoided by using smaller amounts of opaque medium and a very slow rate of injection.

One table and 9 figures illustrating various conditions encountered are included in this paper.—*George W. Chamberlin, M.D.*

SKELETAL SYSTEM

DUBOULOZ, P., LEGRÉ, J., MERJANIAN, R., and SERRATRICE, G. Étude radiologique et valeur statistique des corps vertébraux lombaires à tendance cunéiforme. (Radiologic study and statistical evaluation of lumbar vertebral bodies with cuneiform tendency.) *J. de radiol., d'électrol. et de méd. nucléaire*, 1961, 42, 629-641. (From: Service central de Radiologie de l'Hôpital de la Timone, and Centre médico-social Doria, Marseille, France.)

With the increase in various forms of "socialized" medicine as well as in medicolegal problems, the causal relationship between trauma and wedging of vertebral bodies requires closer scrutiny by the medical profession, particularly the roentgenologists. The authors studied 100 cases suffering backaches following occupational injuries and compared them with 93 volunteers without a traumatic history. Wedge-shaped deformity of the vertebrae was found in 38 per cent in the former group as compared with 7.5 per cent of the latter. While this difference appears to be of statistical importance, the authors emphasize that many conditions other than a post-traumatic status may give rise to the cuneiform tendency. Wedging of multiple vertebrae is found in congenital anomalies and disturbances of growth; e.g. epiphysitis, osteomalacia due to various etiologies, etc. The normal difference in anterior and posterior heights, as measured in the lateral view, is 3 mm. for L1 and 2 mm. for the other lumbar vertebrae. Since wedging is a physiologic characteristic of the dorsal vertebral bodies, this region lends itself less readily for satisfactory investigation. Post-traumatic wedging is more likely to occur in an isolated vertebral body.

The authors make no definite conclusions and admit that the number of patients studied should be far greater before any valid statements on this subject can be made.—*J. Zarusner, M.D.*

ALTMAN, WILLIAM S., and MORACE, VITALIANO. Laminagraphy, an aid in accurate localization in congenital hip dysplasia. *Radiology*, Jan., 1962, 78, 19-28. (Address: 32 Spear St., Quincy, Mass.)

Single-exposure, multiple-plane laminagraphy (book laminagraphy) is the procedure of choice for accurate assessment of the anteroposterior plane of the dysplastic hip. Three cuts are made: through the level of the normal hip, and 1 cm. anteriorly and posteriorly to the normal hip. By this method the gonadal dose is reduced by a factor of approximately 80 per cent when compared with other methods. Satisfactory views were obtained even when a plaster cast had been applied. Few repeat examinations were necessary.

The majority of hip dislocations have been found to be either simple lateral or lateral and cephalad.

- Anterior dislocations were not encountered except in association with trauma or secondary to attempted reduction. Posterior dislocations were most apt to occur in older children whose congenital hip defects had never been corrected. When there is no added anterior or posterior dislocation both hips appear in the same plane on the laminagrams. The diagnostic problem becomes more difficult if there is bilateral displacement because of the lack of a "normal guide." The most valuable information results from post reduction studies.

Illustrative roentgenographic reproductions are included.—*Walter H. Jarvis, Jr., M.D.*

KOLB, FELIX O., and STEINBACH, HOWARD L. Pseudohypoparathyroidism with secondary hyperparathyroidism and osteitis fibrosa. *J. Clin. Endocrinol.*, Jan., 1962, 22, 59-70. (From: Departments of Medicine and Radiology and the Metabolic Research Unit, University of California School of Medicine, San Francisco, Calif.)

Two cases are reported in detail that were similar to the cases described by Albright of the Seabright-Bantam syndrome of pseudohypoparathyroidism. These children have round faces, stubby fingers and toes with short fourth and fifth metacarpals and metatarsals, subcutaneous ossification, low serum calcium and high serum phosphorus levels with mild tetany and no renal failure. There is no phosphaturic response following the administration of parathyroid hormone. The authors' cases showed, in addition, the characteristic findings of hyperparathyroidism; *i.e.*, elevated serum alkaline phosphatase, mild generalized demineralization of bone with subperiosteal resorption of bone about the middle phalanges on the radial side, absence of the lamina dura about the teeth, some areas of bone destruction and mottling of the skull. One case had bilateral slipped femoral epiphyses. The above changes of hyperparathyroidism were reversed following treatment to lower the serum phosphorus concentration. The patients were placed on a low phosphate diet, alumina gel, probenecid and vitamin D. The low serum calcium level and the high phosphorus level returned to normal as did the serum alkaline phosphatase. The short metacarpals and metatarsals remained unchanged and were thought to represent a genetic change and not a metabolic disturbance. The bone age was generally accelerated in these children, and the tubular bones were abnormally wide in the center of the shafts, due to lack of constrictive remodeling by the periosteum.

The Ellsworth-Howard test is discussed. This test estimates the renal phosphaturic response to parathyroid hormone and differentiates between hypoparathyroidism and pseudohypoparathyroidism.

- The coexistence of pseudohypo- and hyperparathyroidism is explained as follows: (a) the lack of response of the renal tubules to parathyroid hor-

none results in retention of phosphate and elevation of the serum phosphorus level; (b) the reciprocal fall of serum calcium leads to tetany; (c) stimulation of the parathyroid glands results in secondary hyperparathyroidism; (d) resorptive changes produced by the osteoclasts result in osteitis fibrosa; and (e) the high phosphorus and low calcium levels persist due to lack of response of the renal tubules to the parathyroid hormone.—*Charles W. Cooley, M.D.*

BARRY, HUGH C. (Sydney, Australia.) Sarcoma in Paget's disease of bone in Australia. *J. Bone & Joint Surg.*, Dec., 1961, 43-A, 1122-1134.

Paget's disease of bone appears to be more common in Australia than in many other countries. The great majority of the patients has neither symptoms nor clinical signs; the diagnosis is made mostly from routine roentgenographic examinations for unrelated reasons. Pain is seldom a complaint, and only rarely does pain present a problem in the treatment. This absence of pain in Paget's disease in Australia is at a variance with the experience of clinicians in other countries. Men are affected nearly twice as often as women.

In contrast to the high incidence of Paget's disease of bone, the development of sarcoma in Paget's disease is rare in Australia. Some surgeons have seen over 100 cases of Paget's disease and have not yet encountered a single instance of malignant change. The author estimates that the malignant changes seen in Paget's disease probably occur in less than 1 per cent. A series of 29 bone tumors arising in Paget's disease (12 not proved by biopsy) that were treated in the teaching hospitals in Sydney during 1950 through 1959 are reviewed. An additional 2 other cases were reported making a total of 31 cases. In 5 of these cases there was a history of trauma prior to the development of the sarcoma, but there is no evidence that a malignant change developed as a result of a fracture or surgical intervention. All of the tumors found were osteogenic sarcomas with the exception of 1 fibrosarcoma, 1 chondrosarcoma and 1 giant-cell tumor.

The treatment of the malignancy consisted in amputation, deep roentgen therapy and palliative measures.—*Peter C. Truog, M.D.*

MESZAROS, WILLIAM T., and SISSON, MELVIN. Myelofibrosis. *Radiology*, Dec., 1961, 77, 958-967. (From: The Departments of Radiology, Cook County Hospital, Chicago, Ill., and Oak Forest Hospital of Cook County, Oak Forest, Ill.)

Myelofibrosis is a syndrome of progressive fibrosis of the bone marrow with myeloid metaplasia and a leukemoid blood picture. The term "myelosclerosis" indicates associated bone formation within the marrow. The condition may be "idiopathic" or "primary," and secondary in association with or from

reaction to certain proliferative processes; *i.e.*, myeloid leukemia, lymphosarcoma, metastatic carcinoma, myeloma, polycythemia vera, and tuberculosis and may also be produced by certain toxic agents; *e.g.*, irradiation and industrial solvents. The marrow is replaced by fibrous tissue, either patchy or diffuse. The bone trabeculae are thickened and new bone formation is present (myelosclerosis). A leukemoid blood picture is noted, and anemia with evidence of abnormal erythropoiesis is the usual finding. On physical examination, splenomegaly or hepatosplenomegaly is present.

On the roentgenogram, the bones may appear normal, even when the marrow examination shows considerable evidence of myelofibrosis. Increased bone density is noted in 30 to 50 per cent of the patients, affecting most frequently the ribs, spine, pelvis, femora, and occasionally the skull. Mottled or "moth-eaten" areas of decreased bone density and occasionally well defined osteolytic areas have been noted. Splenomegaly or hepatosplenomegaly is demonstrable roentgenologically. Periosteal reaction is occasionally observed. A "secondary" gouty arthritis may develop rapidly.

Conditions to be differentiated from myelosclerosis are myeloid leukemia, sickle-cell and Cooley's anemia, metastatic carcinoma, osteopetrosis, Paget's disease, fluorine osteosclerosis, urticaria pigmentosa, and multiple myeloma.

Therapy is largely supportive. The duration of life may vary from months to several years. If there is a pronounced hemolytic component to the anemia, steroid therapy or splenectomy may be indicated.

Three cases are presented with illustrations of the roentgenographic findings.—*Walter H. Jarvis, Jr., M.D.*

HOLLING, H. EDWARD, BRODEY ROBERT S., and BOLAND, H. CHRISTINE. Pulmonary hypertrophic osteoarthropathy. *Lancet*, Dec., 1961, No. 7215, 1269-1274. (From: The Vascular Section of the Edward B. Robinette Foundation, Department of Medicine, and School of Veterinary Medicine, University of Pennsylvania, Philadelphia, Pa.)

Osteoarthropathy is described as a syndrome consisting of (a) nonpitting swelling of the tissues over the ends of long bones, (b) clubbing of the digits, (c) the roentgenographic appearance in distal long bones of periosteal new-bone formation. The etiology is unknown; humoral and neurogenic theories are proposed. Osteoarthropathy, usually in association with chest neoplasms, occurs in the dog. Its development, physiology, clinical course and roentgen manifestations were studied in 5 adult humans and 7 dogs

with lung tumors.

The limbs of the dogs showed an overgrowth of highly vascular connective tissue investing tendons and bones composed of dense collagenous bundles and many thick-walled vessels. Most of the new-bone formation was subperiosteal, but occasionally, in areas of fibrochondroid metaplasia, ossification appeared in the soft tissues.

Blood flow in superficial tissues, vessel and bone was selectively measured and the study suggests that the increased flow was to the thick connective tissue investment; there was no increase in the vascularity of bone. Blood gas studies showed no indication of venoarterial shunt in the pulmonary circulation.

Certain surgical procedures directed to the treatment of the pulmonary neoplasm produced amelioration of the osteoarthropathy with diminution in swelling and blood flow and eventual resolution of the newly formed bone. Some of these effects were obtained after severance of the lung pedicle, after rib resection or incision of parietal pleura. Vagotomy also proved effective.

The primary anatomic change in the limb is the overgrowth of vascular connective tissue and this preceded the formation of new bone. When chest surgery produced regression, it was promptly noted in the soft tissues but resolution of bone changes was not roentgenographically apparent before 5 weeks.

Attempts to substantiate the humoral theory by means of cross-circulation studies gave negative results, but the prompt regression of soft tissue swelling after vagotomy or after interruption of fibers of the vagus during dissection of the lung root strongly supports a neurogenic theory. The authors suggest that underlying pulmonary osteoarthropathy there is a reflex mechanism mediated, in part, by afferent vagal fibers in the lung; the efferent pathways are undetermined.—*Jack Reynolds, M.D.*

GINSBURG, JEAN, and BROWN, J. B. Increased oestrogen excretion in hypertrophic pulmonary osteoarthropathy. *Lancet*, Dec., 1961, No. 7215, 1274-1276. (From: Department of Obstetrics and Gynaecology, Charing Cross Hospital Medical School, London, W.C.2, England, and The Clinical Endocrinology Research Unit, Medical Research Council, University of Edinburgh, Edinburgh, Scotland.)

This is a concise and valid piece of work, revealing the interesting fact that men with pulmonary osteoarthropathy excrete more than twice the amount of estrogen recovered from controls.—*Jack Reynolds, M.D.*

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HEMISPHERECTOMY...surgical removal of left cerebral hemisphere for uncontrollable seizures following infantile hemiplegia

*Radiographs on Kodak Blue Brand medical x-ray film;
surgery photographed on 35mm Kodak Ektachrome film.*

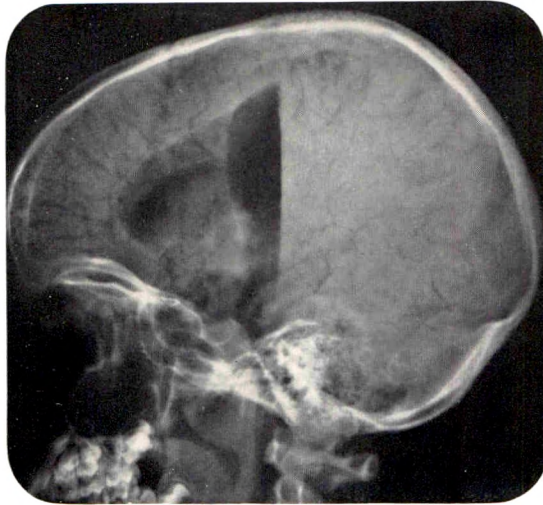


Figure 1. Supine lateral view



Figure 2. Erect lateral view



Figure 3. Prone lateral view



Figure 4. Left side uppermost laterally recumbent view

Pneumoencephalograms (Figures 1 to 4 above) show size and position of grossly enlarged left ventricle. Note that cerebral cortex is markedly thinned in posterior half of hemisphere.

Surgical procedure, Figures 5-10 inclusive

What the radiologist and surgeon saw and what the surgeon did are clearly shown here and on the next page. What is more, when procedures such as these are carefully recorded, the information is available for further study—today, tomorrow, years from now—through color slides and black-and-white and color prints.

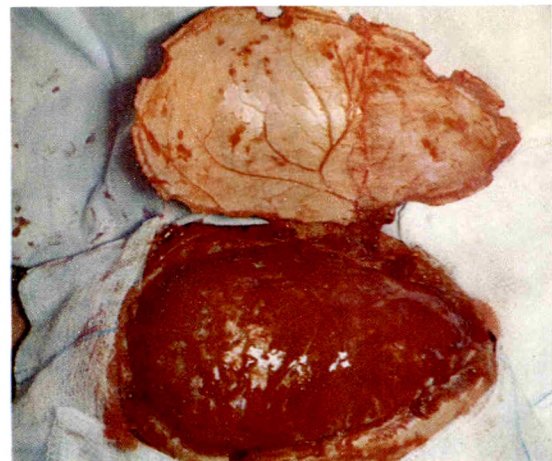


Figure 5. Frontal and parietal bone flap.

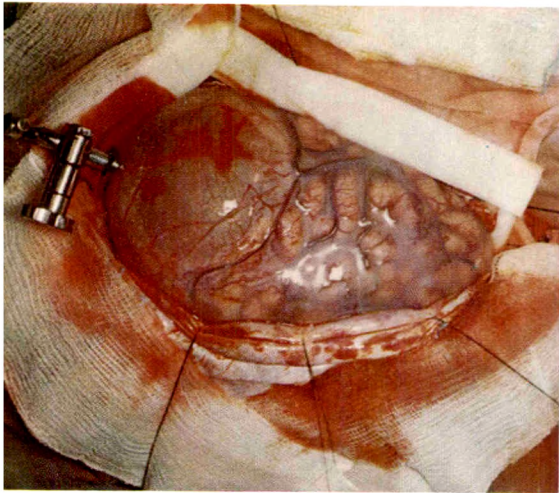


Figure 6. Dura opened, exposing large cyst in parieto-occipital area.

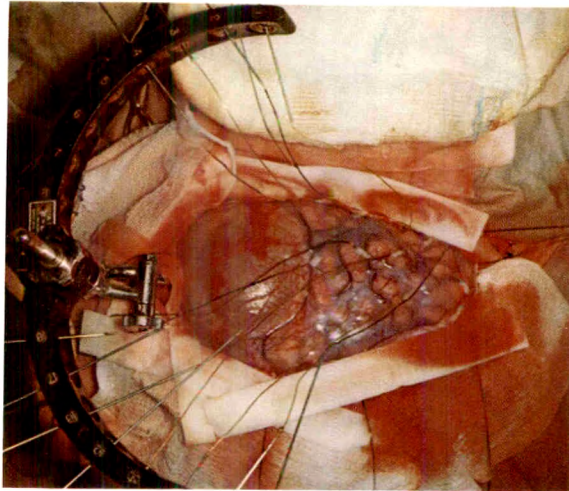


Figure 7. Electrocorticograms being obtained from exposed brain.

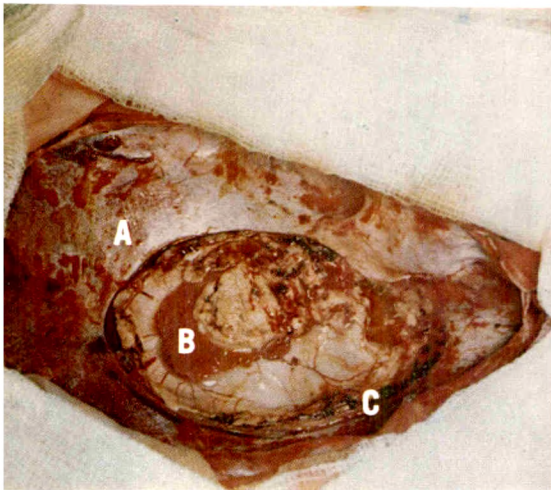


Figure 8. Cavity after removal of hemisphere exposing alx (A), choroid plexus (B) shown about base of thalamus at site of amputation, and tentorium (C).

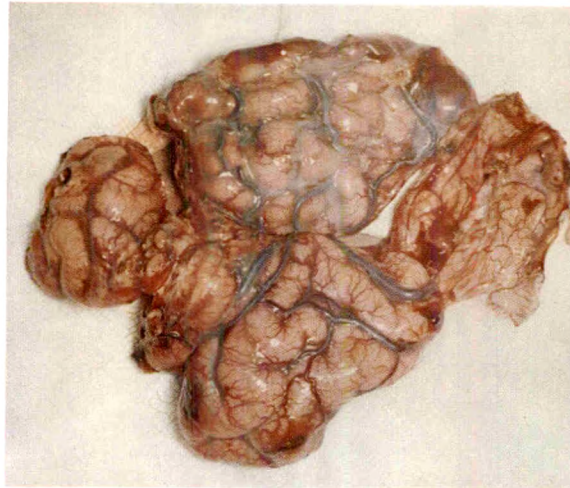


Figure 9. Resected hemisphere, lateral aspect.

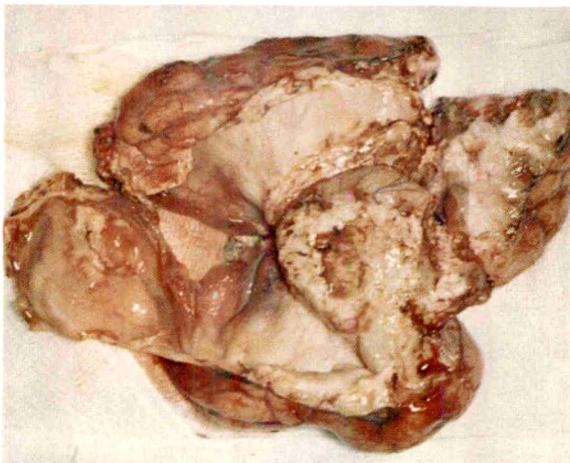


Figure 10. Resected hemisphere, medial aspect.

Note: Following surgery, symptoms ceased. Patient, a 7½-year-old boy, now enjoys normal health.

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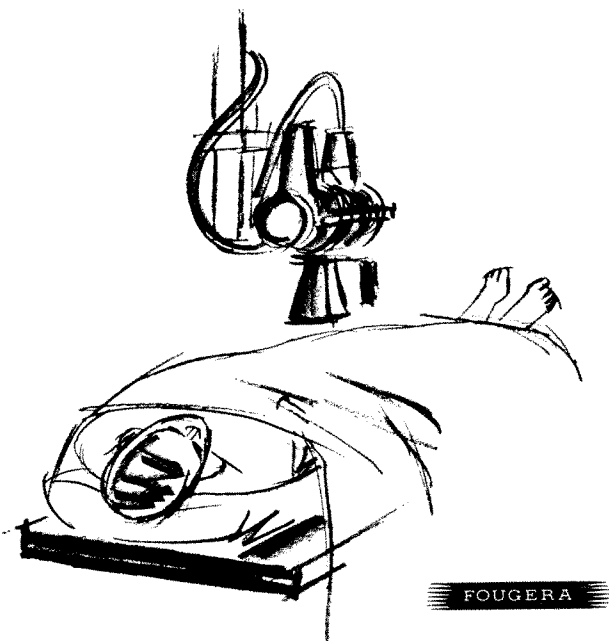
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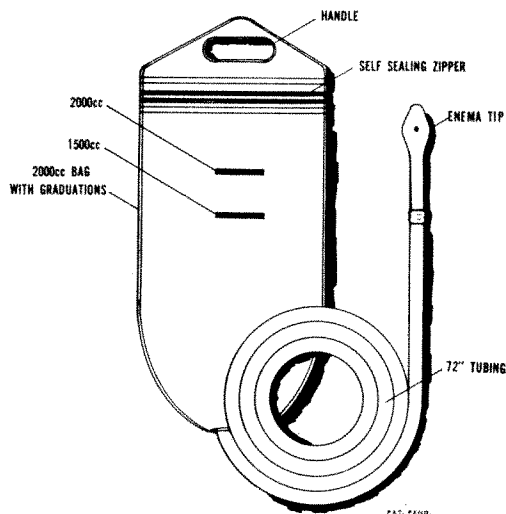
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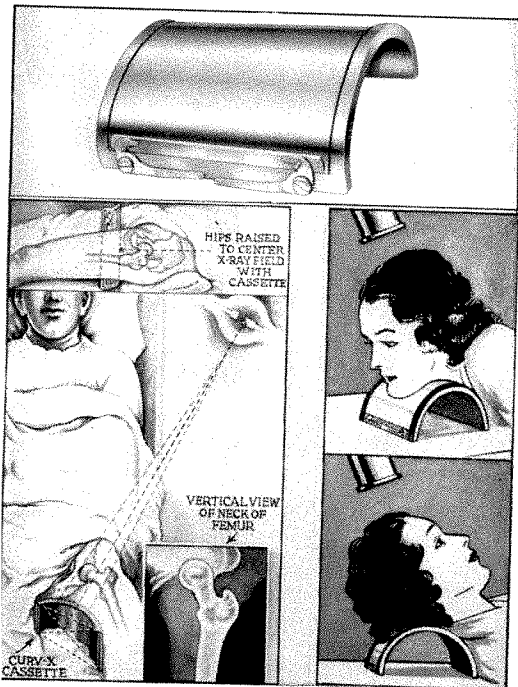


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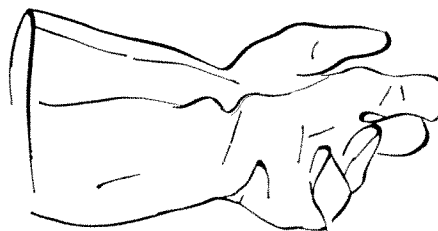
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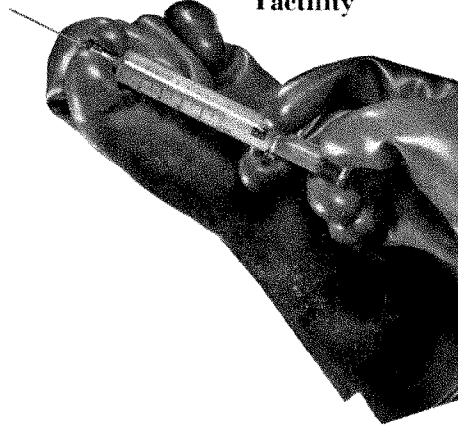
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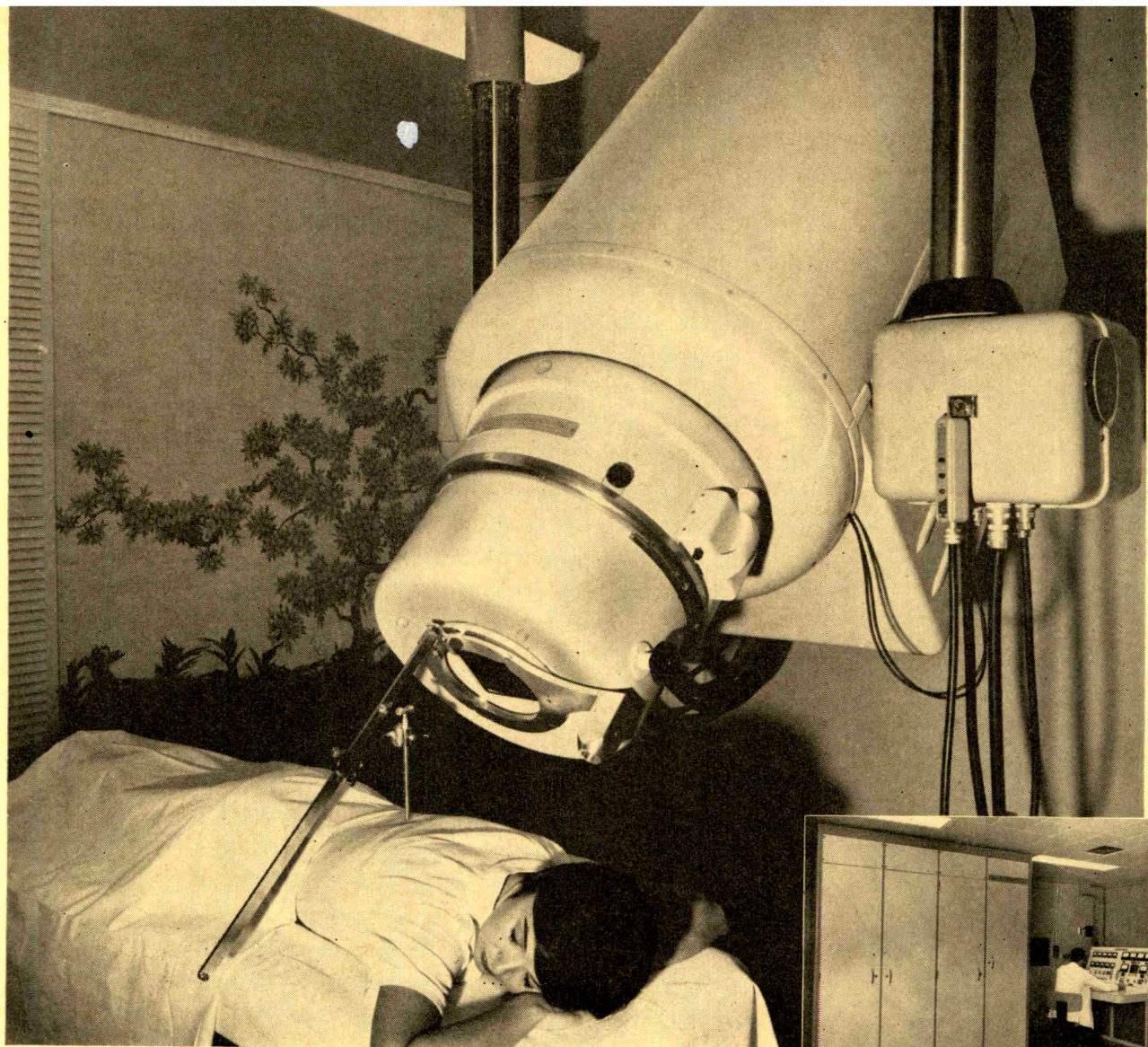
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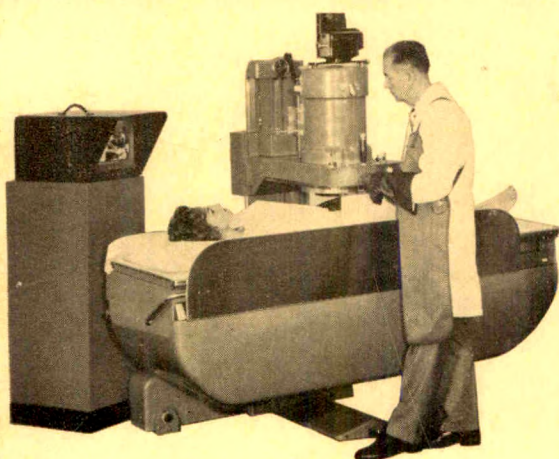
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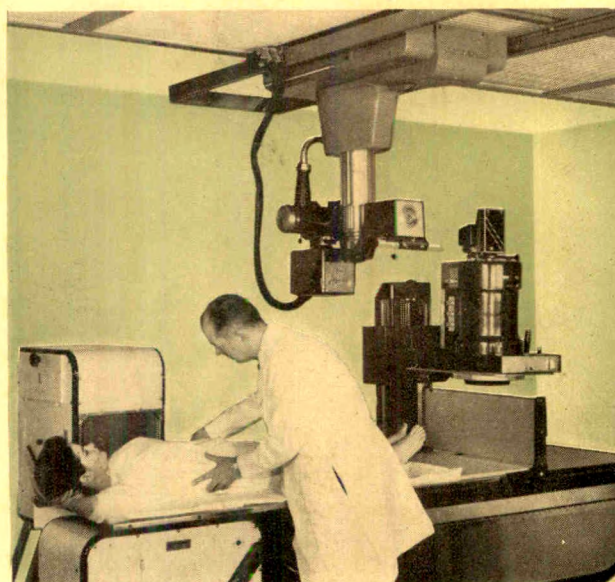
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